New South Wales

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AND ECONOMIC

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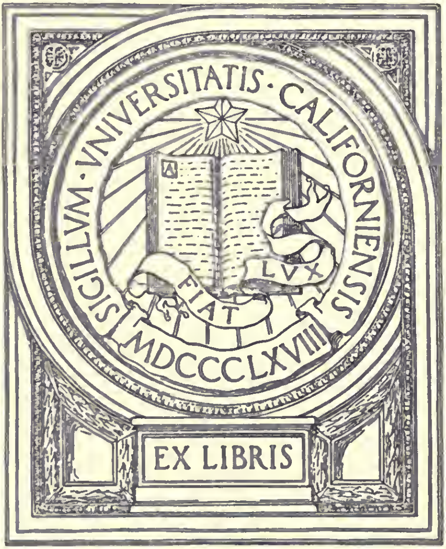

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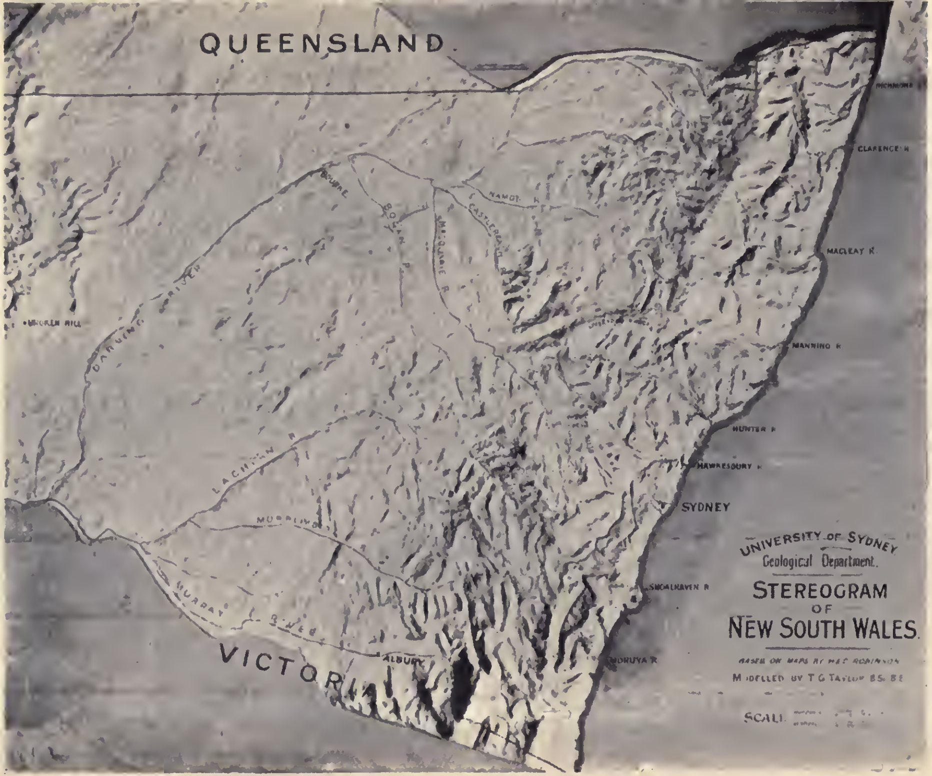

Stereogram of New South Wales.

NEW SOUTH WALES

HISTORICAL, PHYSIOGRAPHICAL, AND ECONOMIC

BY

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PREFACE.

(By T. W. Edgeworth David, C.M.G., B.A., F.R.S., F.G.S., Hon. D.Sc. Oxon, Professor of Geology, University of Sydney.)

The authors of this work, Mr. A. W. Jose, the Correspondent in Australia of the London "Times," Dr. W. G. Woolnough, D.Sc., F.G.S., Lecturer and Demonstrator in Economic Geology at the University of Sydney, Mr. T. Griffith Taylor, B.Sc., B.E., B.A., Physiographer to the Commonwealth Meteorological Bureau, have travelled much throughout the length and breadth of our land, and so, except when matters of early history are being discussed, are able to describe just what their own eyes have seen of this part of the face of the earth.

The history of the coming of civilization to our shores, of its spread inland, of the development of our industries, and of the rise of self-government has already been told by many authors, to whose original works the reader is referred for details of events summarised in this volume.

The tale of how our land has taken the shape it now presents, and as to whence have come its plants and animals and aborigines, is known as yet only in part. The whole truth will never perhaps be known; and yet to win a glimpse of it is glorious.

> "For all experience is an arch wherethro
> Gleams that untravelled world whose margin fades
> For ever and for ever when I move."

421497

Among those who have of late most contributed to the physical side of this story, the name of Mr. E. C. Andrews, B.A.,[*] of the Geological Survey of New South Wales merits special mention. That author, drawing his inspiration chiefly from the works of Prof. W. M. Davis of Harvard University, is seeking to apply the exact methods of physical and mathematical research to interpret scenery as an expression of natural forces. Professor J. W. Gregory, D.Sc., F.R.S.,[†] and Mr. Walter Howchin, F.G.S.[||] in their geographies respectively of Victoria and South Australia have followed somewhat similar methods, as also have the authors of the present volume in regard to the physical geography. It has been decided not to repeat in this book the principles of the evolution of scenery so admirably enunciated by Davis in his work Elements of Physical Geography; and it is presupposed that the reader of the present volume has some acquaintance with Davis's definitions of the various types of land forms.[‡]

In the history of the exploration of New South Wales it has been impossible within the allotted space to do anything like justice to the subject.

The story of our early explorers Cook, Bass, Banks, Flinders, Barallier, Wentworth, Blaxland, Oxley, Sturt Mitchell, Hume, Hovell, Strzelecki, Cunningham and a host of others would fill many volumes. The thrilling history of their splendid endurance and self sacrifice should nerve us for the daily duty of working worthily in this land so hardly won for us by these and others of our heroic pioneers.

---

[*] 1. Physical Geography of N.S. Wales, E. C. Andrews.
2. "Tertiary History of New England," Rec. Geol. Surv. N.S. Wales, Vol. VII.
3. The corrosion, under gravity, by streams, etc,, Jour. Roy. Soc. N.S. Wales, 1909.
4. The Geographical Unity of Eastern Australia, etc.

[†] The Geography of Victoria, Historical, Physical, and Political, by J. W. Gregory, D.Sc., F.R.S. Whitcombe & Tombs Limited.

[||] The Geography of South Australia; Historical, Physical, Political and Commercial, by Walter Howchin, F.G.S., with introduction by Prof. J. W. Gregory, D.Sc., F.R.S. Whitcombe & Tombs Limited.

[‡] These are all well summarised by Andrews in the first of his works mentioned above.

In editing this work I have been greatly assisted by Mr. T. Griffith Taylor, and Dr. W. G. Woolnough; and I should also like to express my gratitude for the kind assistance given in the supply of photographs for this textbook by the Irrigation Branch of the Department of Public Works as well as by the Government Tourist Bureau.

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NEW SOUTH WALES

INTRODUCTION

(T. W. EDGEWORTH DAVID, C.M.G., B.A., F.R.S., F.G.S., Hon. D.Sc. Oxon., Professor of Geology, University of Sydney.)

Reference to the Physiographical Map on page 2 shows that New South Wales may be divided up into the following units:—

NEW SOUTH WALES.

- (1) Coastal Plains.
- (2) Tablelands of the Main Divide.
  - Southern Tableland
    - (a) Monaro Tableland
    - (b) Lake George Geocol.
    - (c) Central Tableland of Goulburn to Blue Mountain Area
  - Hunter Geocol with Great Central Coal-field
  - Northern or New England Tableland
- (3) Western Plains.
  - The Cobar Peneplain
  - The Barrier Range and Mt. Brown Peneplain
  - Sediments of Artesian Water Basin with mound springs and chiefly marine cretaceous clays overlying Trias-Jura Sandstones
  - Sediments of the old Tertiary (Eocene) Sea of Riverina
  - Red Soil and Black Soil Alluvials

These units are also illustrated in the stereogram of New South Wales (see frontispiece). This

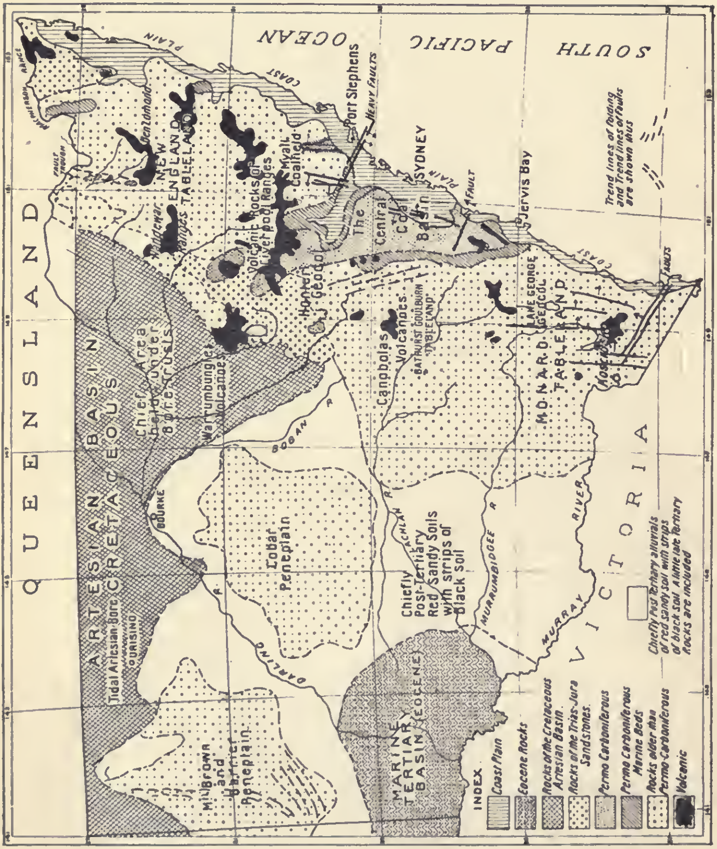
QUEENSLAND
ARTESIAN BASIN
CRETACEOUS
Tidal Artesian Bore
Chief Area under bore crusts
Warrumbungle Volcanoes
NEW ENGLAND TABLELAND
Nandewar Ranges
Volcanic Rocks of Liverpool Ranges
Myall Coalfield
Port Stephens
HEAVY FAULTS
OCEAN
PACIFIC
SOUTH
COAST
PLAIN
SYDNEY
The Central Coal Basin
Hunter Geocol
Canobolas Volcanoes
BATHURST GOULBURN TABLELAND
Jervis Bay
FAULT
LAKE GEORGE GEOCOL
MONARO TABLELAND
KOSCIUSKO
FAULTS
Trend lines of folding and Trend lines of faults are shown thus
BOURKE
BOGAN R
Cobar Peneplain
LACHLAN R
Chiefly Post-Tertiary Red Sandy Soils with strips of black Soil
MURRUMBIDGEE R
MURRAY RIVER
DARLING
VICTORIA
Chiefly red Tertiary alluvials of red sandy soil with strips of black soil. A little late Tertiary Rocks are included
MARINE TERTIARY BASIN (EOCENE)
Milbrown and Barrier Peneplain
INDEX
Coast Plain
Eocene Rocks
Rocks of the Cretaceous Artesian Basin
Rocks of the Trias-Jura Sandstones
Permo Carboniferous
Permo Carboniferous Marine Beds
Rocks older than Permo-Carboniferous
Volcanic

Fig. 1. Map of geographical Units of N.S. Wales

stereogram was prepared by Mr. T. Griffith Taylor, the contour lines being supplied by Mr. H. E. C. Robinson of Sydney.

THE COASTAL PLAIN.

Reference to the sketch map, Fig. 1 and the section Fig. 2, shows that the coastal plain is narrow at its southern end, and first acquires a considerable width when the southern end of the great central coal-field is reached near Jervis Bay. From the Shoalhaven northwards to Coal-cliff it gradually thins out against the steep escarpment of the Blue Mountain portion of the Central Tableland. Further North, west of Botany Bay and Sydney, the coastal plain sweeps inland for a distance of from 30 to 35 miles to the Eastern Escarpment of the Blue Mountains. This escarpment, as originally shown by C. S. Wilkinson, late Government Geologist of New South Wales, is formed by a strong fold with its steep face directed sea-wards, the hinge of the fold trending nearly north and south (see p. 56). By this fold the old channel of the Nepean River has been joggled upwards, and the coastal plain downwards, the total amount of displacement varying from about 500 to 600 feet. This grand earth movement has probably been partly responsible for producing our extensive estuaries and harbours such as Jervis Bay, Port Hacking, Botany Bay, Port Jackson, Broken Bay and Brisbane Water, Tuggerah Lakes, Lake Macquarie, Newcastle, Port Stephens, and the numerous bar harbours further to the north. The soft coal-measure rocks of the Hunter Valley give the coastal plain its greatest extension inland of about 60 miles. To the north of Port Stephens the coastal plain becomes contracted again in proportion as the harder rocks, older than the coal-measures, approach the coast. A short distance to the south of the Clarence River it again widens to fully 30 miles where the soft rocks of the Clarence Basin form the land. At the Macpherson Range, the boundary between New South Wales and Queensland, the coastal plain is once more narrowed on account of the resistance to denudation offered by the hard volcanic rocks which there cap the strata of the Clarence Basin.

The section, Fig. 2, shows the natural subdivisions of this coastal plain.

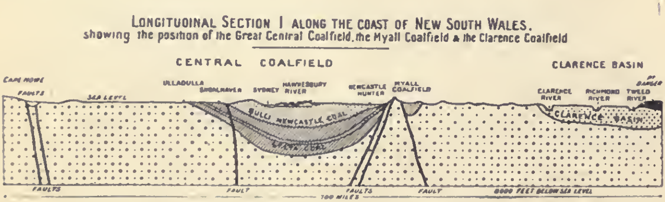

Fig. 2. Section along coast of N.S. Wales.

The question has been raised as to whether the coast of New South Wales belongs to the Atlantic or to the Pacific type.*

In the **Pacific Type** of coast the rocks of the coastal region bend down towards the Pacific in long folds conforming to the trend of the coast, or are faulted down along old earthquake cracks running approximately parallel with the coast. In the **Atlantic Type** of coast no such parallelism can be traced between the trend of the great structures in the earth's crust, such as folds and faults, and that of the shore-line. In the case of the New South Wales coast the older lines of folding and faulting trend mostly in a N.N.W. and S.S.E. direction, whereas the coast trends S.S.W. to N.N.E. A glance at the map (Fig. 1), shows this want of conformity between the trend of the depression or trough, in which lies the great central Coalfield, and that of the coast. But recent earth movements near the coast of New South Wales have swung more nearly into parallelism with the coast. The coast of New South Wales might therefore be provisionally classed as of **Sub-Pacific Type,** as recently suggested by Professor Gregory.

---

*For details see Geography of Victoria, by Professor J. W. Gregory. pp. 32-38.

Evidence of **recent submergence** is strongly marked along the whole extent of the New South Wales coast. In the great central coal-field it appears to have been connected with the downward joggle of the coastal plain, but it is also possible that some of the recent submergence, which amounts to from about 150 feet to 200 feet may be due to the thawing of large masses of ice, partly in the Northern partly in the Southern Hemisphere, subsequent to the climax of the Great Ice Age.*

---

*Thus if the whole area of the ocean is about 145 millions of square miles, and during the maximum glaciation in the Pleistocene Ice Age, ten millions of square miles of the land was covered by ice, and this ice had a mean thickness of half a mile, that is 2,640 feet, and if the earth's surface for the purpose of this calculation be considered a plane, the level of the sea might be raised everywhere by about

$$\frac{2{,}640 \times 10}{145} = \text{about } 182 \text{ feet.}$$

This may perhaps be a somewhat high estimate, but if reduced by one-third, that is to 121 feet, in round numbers, the estimate may be considered well within the bounds of probability.

In regard to the second unit, the Tablelands of the Main Divide, the accompanying sketch section shows at once its natural subdivisions.

Again the dominant feature is the great **central coalfield** with the Hunter Geocol described on p. 85 of this volume. The softness of the coal-measure rocks is obviously the reason for the development of the Hunter Geocol.

Mr. Andrews has suggested that the warping up of the old peneplain of Eastern Australia to its maximum height of 7,300 feet at Mt. Kosciusko may be due to that area being situated just at the meeting point between the east and west line of uplift of Victoria, and the nearly north and south line of uplift of New South Wales. The northern end of the Kosciusko Plateau is dropped downwards by some heavy faults which trend towards Twofold Bay. The highest points of the New England Tableland are formed of the Tertiary Volcanic Rocks, basalts, of Ben Lomond, and the much older volcanic rhyolites, of Capoompeta. Capoompeta is a typical **Monadnock**, that is, a portion of the earth's crust that has been left in high relief on account of its superior hardness having enabled it to resist denudation better than the surrounding rocks. At the extreme right of the section we see the Volcanic

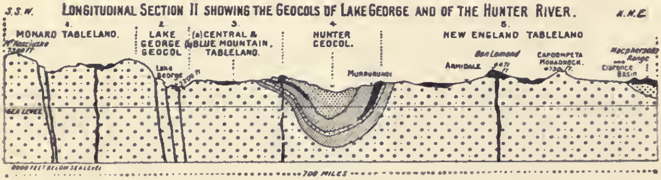

Fig. 3. Section along Main Divide of N.S. Wales.

rocks, mostly basalts, of the Macpherson Range which divides New South Wales from Queensland.

THE WESTERN PLAINS.

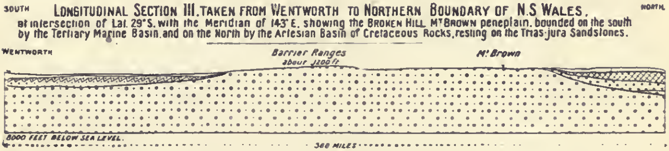
SOUTH
LONGITUDINAL SECTION III. TAKEN FROM WENTWORTH TO NORTHERN BOUNDARY OF N.S WALES,
at intersection of Lat. 29°S. with the Meridian of 143°E. showing the BROKEN HILL M^T BROWN peneplain. bounded on the south by the Tertiary Marine Basin. and on the North by the Artesian Basin of Cretaceous Rocks, resting on the Trias-jura Sandstones.
NORTH
WENTWORTH
Barrier Ranges
about 1200 ft
M! Brown
8000 FEET BELOW SEA LEVEL.
300 MILES

Fig. 4. Section along the western boundary of N.S. Wales.

The above is a generalised sketch section of the Western portion of New South Wales taken on a line approximately parallel with the general course of the Darling River. At once it will be noticed that the great central coal basin does not appear, its place being taken by an extensive massif of old crystalline rocks. On the north side are seen the sandy sediments of the old Trias-Jura lakes capped by the marine sediments of the Cretaceous Mediterranean of Australia. On the south side of the massif are the sediments of the Eocene sea which in early Tertiary time encroached from the South Coast and spread inland as far as Arumpo.

The structure of the Cobar Peneplain on a north and south line is very similar to the above and scarcely calls for special comment. Both these massifs of the Barrier Ranges and of Cobar are more or less covered by extensive **red soil formations** with narrower belts of black soil. The latter represent old silted up river channels, and many of them are still filled with river water in time of flood, and after the flood waters subside support a luxuriant growth of Nardoo (**Marsilea**).

The red soils are of considerable importance on account of their great richness in plant food; they are mostly red sands and red sandy clays, formed largely from the disintegration of the Upper Cretaceous (Desert Sandstones) rocks. Mr. F. B. Guthrie, F.C.S.,* and others have laid special emphasis on this point. An excellent description of much of this type of country is given in the report of the Western Lands Commission.† When methods of **dry farming** are applied to this vast area of red soil country the wheat yield of New South Wales will be vastly increased.

The great importance of the Cretaceous Basin is at once proved by the immense areas of land held by the selectors and pastoralists under the "Bore Trusts" (see p. 166 of this volume). In the Riverina region in the south west of New South Wales there is a considerable area occupied by the sediments of the old Eocene Sea, in which subartesian water may be expected, and the water supply of which will be greatly improved by the Burrinjuck and other irrigation schemes.

If we examine the three E. to W. sections across New South Wales the following features are conspicuous:—

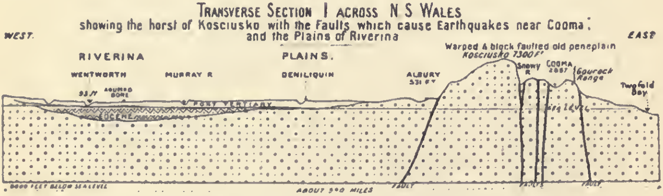
TRANSVERSE SECTION I ACROSS N S WALES
showing the horst of Kosciusko with the Faults which cause Earthquakes near Cooma; and the Plains of Riverina
WEST.
EAST
RIVERINA
PLAINS.
WENTWORTH
MURRAY R
DENILIQUIN
ALBURY 531 FT
Warped & block faulted old peneplain
KOSCIUSKO 7300 FT
Snowy R
COOMA 2657
Gourock Range
Twofold Bay
93 ft
ACURRO BORE
POST TERTIARY
EOCENE
SEA LEVEL
FAULT
FAULTS
FAULT
8000 FEET BELOW SEA LEVEL
ABOUT 300 MILES

Fig 5. Section from the Murray to Twofold Bay

---

*Journ. Roy. Soc. N.S. Wales, Vol. XXXVII. pp. li-lxv.

†Royal Commission to inquire into the condition of the Crown Tenants, 1901, Western Division of N.S. Wales.

This section, from Twofold Bay across Kosciusko and Riverina, shows first the narrow strip of coastal plain, then the fault to the east of the Gourock Range, together with the faults between Cooma and Kosciusko, especially the great fault in which lies the valley of the upper Snowy River. The Kosciusko Plateau sinks partly through faulting, partly through warping (or "flexing") to the level of the Murray at Albury. Further westward the hard ancient rocks of slate and granite are covered over by the red and black soils of Riverina, which in turn overlie the older sedimentary deposits of the Eocene Sea. Subartesian water is met with in the latter.

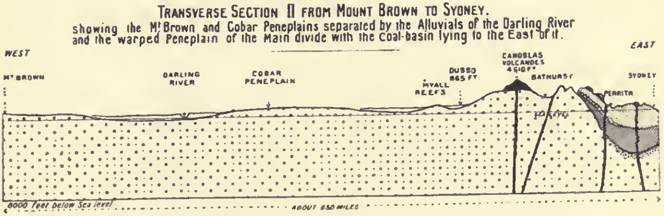
TRANSVERSE SECTION II FROM MOUNT BROWN TO SYDNEY.
showing the Mt Brown and Cobar Peneplains separated by the Alluvials of the Darling River
and the warped Peneplain of the Main divide with the Coal-basin lying to the East of it.
WEST
EAST
Mt BROWN
DARLING RIVER
COBAR PENEPLAIN
MYALL REEFS
DUBBO 865 FT
CANOBLAS VOLCANOES 4610 Ft
BATHURST
PENRITH
SYDNEY
SEA LEVEL
8000 Feet below Sea level
ABOUT 650 MILES

Fig. 6. Section from the Barrier Ranges to Sydney.

This section, from Sydney to the Barrier Ranges, shows the Barrier Ranges peneplain, the belt of shallow Tertiary alluvial deposits of the Darling region, the Cobar peneplain and the warped and faulted peneplain of the Main Divide crowned on the west by the volcanic pile of the Canobolas. To the east are the Blue Mountains, with small cappings of basalt lava. Their strata bend down sharply in a great earth fold W. of Penrith to the inland edge of the coastal plain. This plain is formed of strata, from 5,000 to 7,000 feet in thickness, lying in a deep flattish basin under the Sydney area.

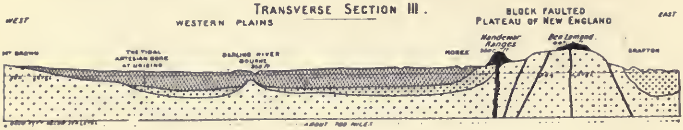

Fig. 7. Section from Mount Brown to Grafton.

This section shows the structure of the northern part of New South Wales from Mount Brown to the Pacific near Grafton. Immediately to the east of the gold-bearing rocks of Mount Brown succeeds the great Cretaceous basin covering the porous sandstones of the Trias-Jura formation which contain such vast supplies of artesian water. These porous beds outcrop to the east of Moree, where they are partly capped by the trachyte lavas of the Nandewar Ranges. Then follows the block-faulted plateau of New England with the old metalliferous rocks containing gold and tin, etc. This plateau descends in a steep slope eastwards into the coastal plain formed of the soft shales and sandstones of the Clarence Basin of Trias-Jura Age.

Summary: Physiographically New South Wales consists of immense tablelands and plains of ancient hard rocks, often highly crystalline, ranging from Archæan to Carboniferous in geological age, and containing lodes and reefs of gold, silver, copper, lead, zinc, tin, antimony, bismuth, molybdenite, tungsten, etc. In the heart of this vast **metalliferous area** is the great **Central Coal Field** having a seaboard of 200 miles, and conveniently situated for supplying the needs of the Northern and Southern and Central Tablelands. This great basin of soft rocks is duplicated in the Clarence District by another deep and extensive basin of soft rocks somewhat newer in age, the Trias-Jura of the Clarence series.

In the north west is the great **Cretaceous artesian basin**, and in the south west the **subartesian basin** of Riverina.

In Cretaceous geological time we see rivers like the Bogan, Macquarie, Castlereagh, Namoi, Gwydir, etc. or rather ancestors of those rivers following their present general trend, emptying by separate mouths into the Cretaceous sea which then washed against the western foothills of our Main Divide between Dubbo and Yetman. (See Fig. 1). Later a gradual uplift of this old Cretaceous sea took place from the Gulf of Carpentaria to Coonamble, the hinge of the movement being perhaps along the Cobar to Broken Hill axis. This uplift joined by the method of "Engrafting" (See Davis) the Bogan, Macquarie, Castlereagh, etc., rivers on to the Darling River. The direction of flow of these rivers to the N.N.W. or N.W. is thus easily understood, as well as the unusual angle which they make at their junction with the Darling River, a newer river than they, started on its career by the north to south tilt of the Cretaceous basin. They thus form, with the Darling, the gigantic "**boat hook bends**" so well described by Mr. T. G. Taylor.*

The North to South tilt of the Australian Continent in late Cretaceous time depressed the Southern part of Australia beneath the ocean, so that the waters of the Eocene Sea crept inland to beyond Wentworth, and at least as far as the Arumpo Bore. Later still a slight tilt took place in an opposite direction bringing the sediments of the Eocene Sea above sea level, engrafting the Murray, Murrumbidgee and Darling, and pushing the coast line from above Wentworth down to its present position on the Coorong.*

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*The Physiography of the proposed Federal Territory at Canberra, p. 8 and figs. 6 and 7.

During this upward movement in the interior of New South Wales the coastal portion underwent a marked elevation, the warping attaining a maximum at the meeting point between the Victorian East and West and the New South Wales North and South directions of uplift. This uplift was greater towards the coast and less inland. Hence the Eastern flowing rivers with their steep grades were able to cut deep cañons and push back the Main Divide westwards.

This process is doubtless still in progress. Heavy block faulting and some folding accompanied these elevations, and to them are due such structures as the upper portions of the Snowy and Murrumbidgee Valleys, the Gourock Range escarpments, Lake George, the Eastern escarpment of the Blue Mountains, the Kurrajong Fault, etc. Lastly ensued a submergence of the coast line to the extent of from 150 to 200 feet, and to this we owe our priceless possessions of so many excellent harbours which result from the drowning of our old land valleys.

When all these natural advantages, our great **metalliferous tablelands**, our immense **central coal basin** with its 100,000 millions of tons of exploitable coal, our **fine arable** and **dairy lands** where the rainfall is good, our **red soils** so rich in plant food and so suitable for dry farming where the rainfall is low, our large **artesian** and **subartesian basins** with all their pastoral and agricultural potentialities, and last and not least our many admirable **natural harbours**, are considered together, we have every reason to be devoutly thankful that our lot has been cast in so fair a ground, and should ever be mindful of the divine behest, "freely ye have received, freely give."

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*See The Geography of Victoria, by J. W. Gregory, p. 120.

PART I.—HISTORY.

(A. W. JOSE.)

CHAPTER I.—SITUATION AND BOUNDARIES.

New South Wales is a State of the Australian Commonwealth, which stretches back from a section of its south-eastern coast to the boundary of South Australia. This western limit is the line of longitude 141° east: from it the line of latitude 29° south forms the northern boundary till it intersects the Macintyre River; the boundary then follows that river and the Dumaresq to the Main Dividing Range, and curves north and east so as to leave the valleys of the Clarence and Richmond inside New South Wales, reaching the coast at Point Danger. The southern boundary follows the River Murray from longitude 141° to its source, and then takes a straight line to Cape Howe.

But this is only the remnant of the original New South Wales. When Britain first took possession of it in 1788, the name was applied to all Australia east of longitude 135°; and in 1831 the western boundary was moved to 129°. Five years later the province of South Australia was carved out of this huge territory by drawing lines on the map at latitude 26° and longitude 132° and 141°. Victoria was cut away in 1851, and Queensland in 1859 (with 141° as its western boundary): and the outlying areas which still nominally belonged to New South Wales were during the next four years divided between Queensland and South Australia.

So when New South Wales calls itself (as it often does) "the mother-State of Australia," it is doubly right; for it was not only the first founded of the Australian colonies, but actually at one time contained all of them except Western Australia.

Politically, the State includes two small islands lying far out in the Pacific Ocean, Norfolk Island and Lord Howe Island: but Norfolk Island will probably be soon transferred to the direct government of the Commonwealth.

To understand properly the progress of settlement and industry in New South Wales you must always keep before you a clear picture of its general shape, for on that everything has depended. Remember, then, that the main range, which forms its watershed, runs practically parallel to the coast for its whole length, (except for a sharp western bend about latitude 32°), at a distance varying from eighty miles in the north to forty near the southern border. From the watershed to the sea runs a tableland cut into deep gorges by comparatively short rivers fed by a heavy rainfall: the mouths of these rivers, when they were discovered, were blocked with sandbars, so that only small ships could enter them conveniently, and at only two places along the whole coast-line (Port Jackson and the mouth of the Hunter) was it possible to go any distance inland without being entangled in a maze of cliff-sided gullies. But westwards from the watershed the land is very differently shaped. The tableland, draining into long rivers fed by an inconstant rainfall, slopes gradually for 100 or 150 miles to the great inland plain. Among its foothills, whose gullies shelter fine areas of fertile soil, it was easy to pass north and south, which was almost impossible across the deeply scarred coastal plateau. And the great plains, when you come to them, stretch away westwards four hundred miles and more, wonderfully fertile if only there was a steady rainfall, but not available for serious cultivation until some form of permanent water-supply is devised, or until the population has so far increased as to make "dry farming" possible.

CHAPTER II.—DISCOVERY AND EXPLORATION.

(A. W. JOSE.)

This land* was for many centuries peopled only by tribes of the race we call "blackfellows," who came into it from the north and west. It is possible that the Portuguese, who were exploring New Guinea in 1526, may have come down along the coast and looked at the country: if they did, they said nothing about it, because they had an arrangement with Spain by which lands east of 147° longitude were to belong to her, and it was no business of theirs to tell her where to find new colonies. As for exploring Spaniards, they had to come across the Pacific Ocean from South America, and the prevailing winds along that route always thrust their sailing-ships north into tropical latitudes before they came near the Australian coast. When in 1642 **Tasman,** the Dutchman, was sent from Java to seek out the unknown lands of the Southern Ocean, and in the search discovered Tasmania, he made an attempt to coast along it northwards, but head winds forced him off shore to the east.

And so the first white man of whom we can certainly say that he saw New South Wales was **Captain James Cook.** (Fig. 8). He had been zigzagging across the South Pacific under orders to look for a supposed continent thereabouts:

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*In future "this land" and "New South Wales" will mean the *present* State of New South Wales.

Fig. 8. Captain Cook.

he found and sailed round New Zealand, and was making for the Tasmanian coast, which Tasman had found, when a storm drove him out of his way northwards. Australia, you see, owes a great deal to the winds of the Pacific. On April 19th, 1770, Cook found that his ship, the *Endeavour*, was sailing towards a long stretch of low sandy beach not marked on any map, and decided to follow it northwards until he came back to known lands. Almost immediately he sighted Cape Howe, and for three weeks and more skirted what is now the coast of New South Wales, naming its prominent features sometimes from their shape—Mount Dromedary, the Pigeon House, Cape Long Nose, and so forth—sometimes after officials of the British Government—as Port Jackson, Port Stephen, and Capes Howe and Hawke. By sheer good luck he made a landing near the only place on the whole coast where a fine

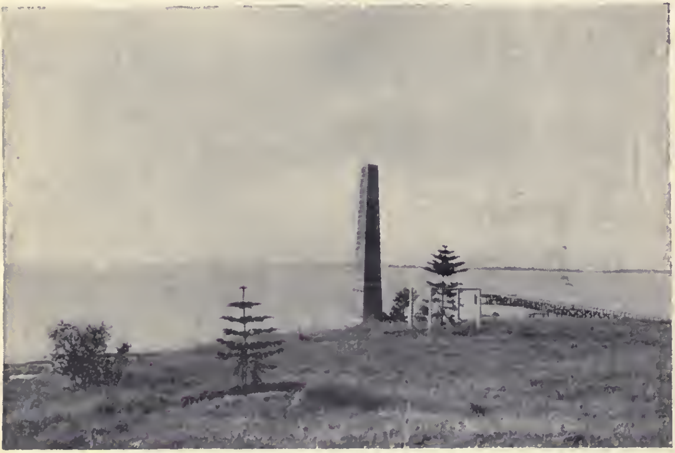
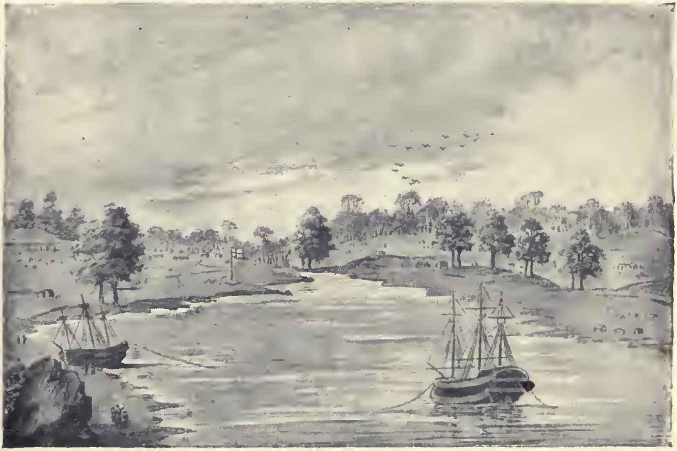


Fig. 9. Kurnell, Botany Bay. The first landing place of Captain Cook in Australia on 28th April, 1770. The monument was erected in 1870, and the vicinity dedicated a public park in 1899.

harbour gives easy access to the interior: the district behind Botany Bay and Port Jackson is about the only area, close to the coast, of fairly open and tillable country not subject to floods or too much cut up by rocky gullies.

Cook was not much impressed with the value of his discovery, and on his return to England apologized to the Admiralty for not doing better. But a young naturalist who accompanied him, Joseph Banks by name, though he at first called it "the most barren country I have seen," grew by degrees into a fondness for it that lasted his lifetime. More especially he remembered that at Botany Bay he had seen the shores, as far inland as he could walk, covered with "vast quantities of grass": and, when propositions were made for colonizing the new country with convicts from England (in 1779) or with loyalist refugees from the



Drawn by E. Dayes from a sketch by J. Hunter.

Fig. 10a. Sydney Cove in 1788.

revolted American colonies (in 1783), he supported them actively, and seems to have decided the British Ministry in favour of the settlement that was at last made in 1788.

With this settlement the history of exploration begins. **Governor Phillip** found himself stranded in a land whose fertility had been much exaggerated (for the rank swamp-grass, that Banks saw, had been magnified into "the finest meadows in the world" and "deep, black mould, fit for the production of grain of any kind"), and was forced to hunt high and low for tillable soil and other sources of food-supply. Planting his headquarters at Sydney Cove on Port Jackson, he personally explored westwards to the Nepean, and as far north and south as the ranges would let him, thus opening up a good area of farm-land. At the same time

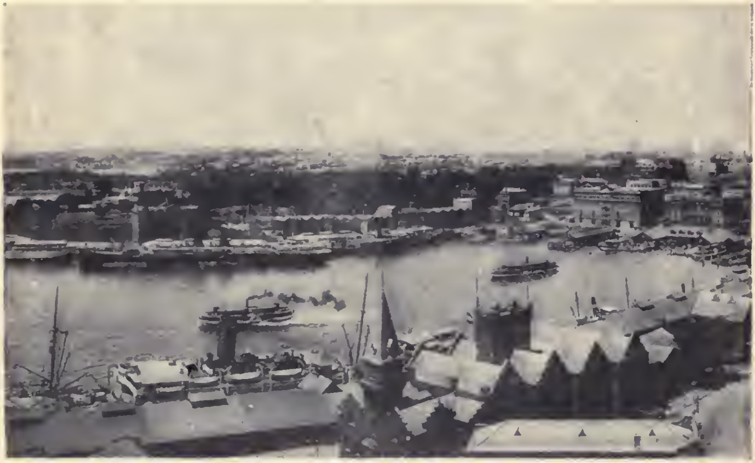


Fig. 10b. Sydney Cove (Circular Quay) in 1911.

he sent **Lieutenant King** to occupy Norfolk Island, which had been discovered by Cook in 1774: and from that time (except for the twelve years between 1844 and 1856, when it was annexed to Tasmania) the island has been either a part of New South Wales or administered by its Governor.

Phillip's successors troubled themselves little about exploration by land. They were naval men: they had a body of convicts to guard, and liked the small patch of settlement, walled in by steep hills and rugged gullies, too well to encourage attempts at breaking through the barriers. What they did want was more patches of the same kind, accessible from the sea only: and they willingly helped young adventurers who went voyaging along the coast. The first of these were **George Bass** and **Matthew Flinders**, who, in March, 1796, ran the shore-line down to Wollongong; Bass followed this up next year with a whaleboat trip right down the New South Wales coast past Cape Howe to Western Port in what is now Victoria. The same year **Shortland** entered the mouth of the Hunter, and found coal lying about there; and in 1799 Flinders surveyed the northern coast as far as Hervey Bay, in what is now Queensland. But New South Wales profited little by these and the many other important nautical explorations of those years: the settlement at Newcastle which resulted from Shortland's discovery was the only consequence of any value.

All this was altered when in 1810 **Lachlan Macquarie** became Governor. He was a soldier, and held that his duty was not so much to guard convicts as, by reforming them, to establish in Australia a colony of free men. For this the first necessity was much more land on which to settle both the reformed convicts and any free settlers who could be induced to emigrate. So exploration inland, which had been either pooh-poohed or carried on half-heartedly or for purely scientific reasons, took a new start. The western side of the Nepean valley is edged by a steeply rising section of tableland, known as the "Blue Mountains," whose barren and rocky summit is cut into ridges by the huge gorges of the Cox and Grose and their tributaries. To follow these gorges up had been found impossible, because of their narrow and boulder-strewn floors and sides of sheer precipice: but **Gregory Blaxland**, advised by Macquarie and accompanied by **Lieutenant Lawson** and a young colonial-born adventurer, **William Charles Wentworth**, traversed the barrier in 1813 with comparative ease, by the simple device of keeping along the main ridge above all the gullies until he reached the beginning of open grass lands to westwards. Along this track a road was promptly made, and the Western Railway many years later could find no more convenient way over the range.

The road once open, the western foothill country was soon explored and mapped out. **George Evans**, the Government surveyor, discovered two large rivers running west, which he named, after the Governor, the Lachlan and the Macquarie: and on the latter in 1815 was laid out the first of Australia's inland townships, Bathurst. **Hamilton Hume** in 1814 worked up the Nepean valley on to the southern tableland, and explored the country in that direction to beyond Goulburn. **John Oxley**, the Surveyor-General, in 1817 and 1818 tried to follow Evans' rivers through the plains to their outlet, which he supposed to be either on the north-west coast of the continent or in some great inland sea: in both cases he reached impassable swamps, and on his second journey struck eastwards for the coast from the lower Macquarie, thus crossing the broad Peel valley (which he called the Liverpool Plains), and coming down over the rough coast ranges to Port Macquarie. An easier route to the Plains was made available by **Allan Cunningham's** discovery, in 1823, of the Pandora Pass near the head of the Goulburn River: and the same explorer in 1826-7 pushed further northwards over the Namoi and Dumaresq on to the Darling Downs, which are now part of Queensland, but which remained for many years a part of Sydney's trade area, because the ranges between them and Brisbane were so difficult to cross. The southern foothill district was being opened up during the same years partly by the natural progress of settlement, which soon spread over the upper Murrumbidgee valley on to Monaro and down the Snowy River, and partly by the enterprise of Hamilton Hume. He, with an old sea-captain named **Hovell**, plunged into the maze of gullies that lies south of the Murrumbidgee, scrambled across them by native paths and kangaroo tracks into the valley of the Upper Murray, and from there found his way to the western shores of Port Phillip.

By 1827, therefore, the western slopes of the Dividing Range in its course through New South Wales were fairly well known in all their main features. The eastern side of the range, however, was still unexplored, except (*a*) the district behind Sydney, (*b*) the Hunter-Goulburn valley, which lay open to settlers directly the river-mouth was discovered, and a patch north of the mouth at Port Stephens which was being slowly put into use by the Australian Agricultural Company, (*c*) the Illawarra strip of rich soil on the south coast, which had been opened up by adventurous cedar-getters, (*d*) a patch of settlement at Port Macquarie. The other coastal districts were made known gradually, partly by enterprising settlers working seawards from the main range, partly by the sailing-boats that traded northwards to Brisbane and south to Tasmania and Port Phillip, and put in to shore occasionally anywhere on the way where there seemed to be a river mouth or a promising harbour.

The great inland plains still remained almost unknown in 1827. But just then a two years' drought, which dried up the marshes that had blocked Oxley, gave opportunity for their exploration. In 1828 **Charles Sturt**, the greatest of Australia's explorers, was chosen by Governor Darling to complete, if possible, Oxley's interrupted task. He followed the rapidly drying Macquarie into a network of shallow channels, rode haphazard across country till he lit on the Darling River (which he found quite salt, since brine-springs in the bed of it were not diluted to freshness by any considerable body of water coming down), and after many weeks' careful search over more unpromising country returned to Sydney with reports that settlement in that direction was hopeless. Next year he was sent off to follow the Murrumbidgee, whose strong and perennial flow gave promise of better things than the dry Macquarie and the briny Darling. He marched along its banks to the swampy district near the Lachlan junction, then boated down the swift stream to the Murray, and on down that to its mouth in Encounter Bay. But the ship he had hoped to meet there was not to be seen, and he had to return a thousand miles upstream, fighting all the way the current which had helped him down so easily. It was a disastrous journey for himself and his men, but it meant the discovery of

Australia's largest river, and the founding of South Australia.

Sturt's work, after all, left two ragged ends. To **Sir Thomas Mitchell** fell the task of connecting them, and joining up into one great river-system the streams found by Oxley, Hume, and Sturt. This he did in two journeys during 1835-6, in the first of which he followed the Bogan to the Darling and that river to Laidley's Ponds, three hundred miles downstream. The season had been a good one: the Darling was full and fresh, and the plains well-grassed. Sturt's unfavourable opinions evidently held good only in time of drought. Encouraged by this, Mitchell next year traced Oxley's Lachlan to the Murrumbidgee, travelled on to the Murray and down to the junction of the Darling—up which he went far enough to identify it—then back up the Murray to where the Loddon enters it. By that time it was evident that the streams Hume had crossed on his way to Port Phillip must flow to the Murray: so Mitchell struck away from its banks into lands that he compared to Paradise, and marched south to the Glenelg and east to the range behind Port Phillip, returning to Sydney along Hume's tracks.

With this expedition the exploration (properly so called) of New South Wales comes to an end—except for another of Sturt's disastrous journeys, which started from South Australia in 1844, and traversed the region west of the Darling during one of the hottest summers ever known in Australia. The explorers, from 1788 to 1836, made an outline sketch of the colony's principal features: the filling-in of it was left to the advancing settlers, with whose story we must now deal.

Chapter III.—THE SPREAD OF SETTLEMENT.

(A. W. Jose.)

It is possible that the task of colonizing New South Wales might have been easier if the first settlement had been made at the mouth of the Hunter. The coal of that district would have from the first given the young colony an export trade; the upper valleys of the Hunter and the Goulburn are far more fertile than the backlands of Port Jackson; and the road to the interior, owing to that great western bend of the Main Divide noted in Chapter I., is an easy gentle slope leading directly to the noble Liverpool Plains. But these very advantages made the Hunter valley unsuitable for the work which the early Governors had to do: and the frequent flooding of the lower Hunter, whose two principal tributaries enter it at such an angle as to block its own waters from running off in times of heavy rain, would make its neighbourhood unfit to be the permanent headquarters of an important State.

Putting that valley aside, there is no part of the New South Wales coast so fit for a centre of settlement as Port Jackson. It is the finest and safest harbour of the continent, and became at once the natural depot for supplying not only the colonists but also the many ships that went trading or exploring or whaling in the South Pacific. In 1802 the French explorer Peron saw vessels lying there on their way to New Zealand, to China, to the western shores of America: coalships ready to start for India and the Cape of Good Hope: traders fitting for the voyage to Samoa or Tonga or Tahiti: sealers just off to Bass Strait. "This constant movement of shipping," he wrote, "impressed these shores with an activity which we were far from expecting in a country so lately known to Europe."

Behind the port, however, though nearly a million acres of land were then available for the use of barely seven thousand people, little was being done with it. A strip of thirty miles along the Hawkesbury was cultivated for maize and wheat, but a great deal of the produce was made into "rum" (*i.e.*, crude spirits), the sale of which enriched many of the early officials. Phillip had brought out sheep and cattle, but the cattle got away into the bush, and the sheep had to be eaten: when in 1795 the descendants of the strayed cattle were found on good pastureland beyond the Nepean, they were left there as a Government herd, and settlement in the neighbourhood was strictly forbidden. But in May, 1797, merino sheep were brought from the Cape, and a few sold to **John Macarthur**, who had already begun to study sheepbreeding: in 1805 Macarthur brought more from England, the pick of King George's own flock, secured for him by Sir Joseph Banks: and after a struggle with Governor King he was allowed to take up part of the reserved land across the Nepean for use as a stud-sheep-farm.

His success was immediate, and encouraged other landowners to try sheep-farming also. But that requires much land; at once the Sydney backlands grew too small, and the discoveries of Blaxland and Evans were eagerly followed up by rich settlers, who occupied large blocks of fertile river-flat as pasturage for their flocks. Bathurst after 1815, and Goulburn after 1820, became starting-points for young flock-owners, who pushed out with their sheep into the foothill country, looking for pastureland along the tributaries of the Macquarie or Lachlan or Murrumbidgee. The valley of the upper Hunter was about the same time made accessible by a track which ran from the Hawkesbury valley at Wiseman's Ferry to Singleton's Inn on Patrick's Plains; settlers gradually took up the Goulburn valley, and a few passed by Cunningham's track to the Liverpool Plains. This sudden expansion of the bounds of settlement was made possible by the arrival in the years succeeding 1822 of many young Englishmen with capital, to whom land was given provided that they spent a certain amount on it and employed a certain number of convict labourers, whom the Government must otherwise have supported. Under this system three and a half million acres were alienated within eight years, whereas Macquarie in twelve years had disposed of less than a million, and his predecessors of a bare two hundred thousand.

When the rush began, Governor Brisbane tried to keep it within control, and even planted a township at Wellington, 238 miles away from Sydney. But the task was obviously too difficult and expensive. In 1825 orders came from London to restrict settlement within certain bounds, and forbid the taking up of land beyond them: Mitchell accordingly surveyed the "nineteen counties"—an area bounded roughly by the Manning and Moruya Rivers to north and south, by the bend of the main range on the north-west, and on the west by a line drawn from Wellington to Yass. In them land might be granted, or, after 1831, sold by auction at not less than five shillings per acre (in 1838 the minimum was raised to twelve shillings): outside was *taboo*—a settler who crossed the border was just a trespasser, and might be ordered off the land he had chosen to occupy. Some who did so were not merely trespassers, but thieves, who stole their nearest neighbours' sheep and cattle and drove them into the bush beyond reach of pursuers: for them the name "squatters" was borrowed from the United States, and soon came to be applied to all who drove their sheep beyond the bounds of legal settlement, following Mitchell and Cunningham into the Upper Darling country, or Ovens and Hume to the Snowy River and the Upper Murray. The drought of 1827-9 checked them for a while, but in Governor Bourke's time they were as venturesome as ever.

In 1824 the Australian Agricultural Company, a body of prominent London business men, had been chartered to cultivate waste lands within the colony, and had taken up a million acres near Port Stephens. Finding much of this land unfit for sheep, the Company asked for a new block of good sheep-country just outside the bounds of settlement on the edge of the Liverpool Plains: when Bourke refused it because squatters were already in occupation, the Company appealed to the British authorities and he was forced to hand it over. This obvious injustice set Bourke devising means to legalize the squatters' position; in 1836 he started a system of annual licenses, which was enlarged by the next Governor, Gipps; and the area outside the "twenty counties" (Port Macquarie and its backlands had been made the twentieth in 1838) was divided into eight pastoral districts, in which licensees might run sheep and cattle, but no man could buy land. Meanwhile the British Government made preparations for splitting up the colony by proclaiming three "Land Districts," the Southern or Port Phillip District reaching north to the Murrumbidgee, and the Northern or Moreton Bay District south to the Manning: but protests from New South Wales caused an alteration of the boundaries to the Murray and the Dumaresq.

Till 1851 the official plan of settlement was clear and simple. It is well shown in the squatting regulations of 1847, by which three classes of land were established. "Settled" land—the twenty counties, the seacoast for three miles inland, the banks of the Clarence and Richmond Rivers, and land near certain large towns—could be bought for not less than a pound an acre, or leased for not more than a year at a time; these areas, therefore, would be always quickly available for purchase by farmers or other permanent settlers. In an "intermediate" belt leases might be granted for eight years at a time, and even then the leased lands might be sold at sixty days' notice. The rest of the colony was "unsettled," and could be leased in fairly large areas at rents proportioned to the stock they could carry. Thus the whole colony could be put to some use; but permanent settlement, carrying with it the construction of good roads, the provision for police and education, and other expensive but convenient requirements of civilized life, would spread gradually outwards from the centres of population.

All this contriving was upset in 1851. Gold might be found anywhere; gold brought diggers, and diggers must be fed. The rush to some obscure gully of the main range was soon followed by the demand that fertile patches in the neighbouring gullies should be thrown open for tillage. Sir John Robertson's Land Act of 1861 tried to provide for this need by allowing "selectors" to take up any Crown land they liked, whether it was leased or not, provided that no one selector could take more than 320 (afterwards increased to 640) acres, and that the taker must live and work on his selection. Now the big landholders (except those who had obtained grants in the early days) had found it much simpler during the forties to lease land than to buy it for £1 an acre—which indeed it was not then worth: so a great part of their estates, even in the settled districts, could be taken away by selectors. There were men who traded on this, selecting the best-grassed or best-watered portions, which the squatter must have, and waiting till they were paid to abandon them. The squatters in their turn tried to prevent this form of blackmail by inducing their own employees (or hiring other people) to select such portions, on the understanding that no use would be made of them: this "dummying" was, of course, quite contrary to the intention of the Act, and gave many squatters the undisturbed use, for sheep only, of land not far from townships which was really suitable for wheat-growing.

From 1861 onwards, therefore, we find a fierce war going on between squatter and selector, which seriously hampered the progress of settlement and led to the misuse of much territory. The accessible areas of fertile land east of the great watershed had been disposed of, and were little affected. It was the tableland of the main range and its western foothills that were in dispute, leaseholders "dummying" or scraping together all the cash they could raise to secure themselves in possession of the best and most accessible areas, so that selectors in search of farming-land were forced into remote and rocky gullies or out on to the drier western plains. Failing there, as was natural, they were glad to sell their little blocks cheaply to the holder of the land round them, and many a station of to-day is largely made up of selections thus purchased. The net result was rather startling. In thirty years the system which was to have settled a large population on the soil had added barely 200,000 to the country-folk, while the townsfolk had increased by nearly 600,000: and, while in 1861 the average size of holdings was 280 acres, in 1893 it had grown to 762 acres.

On the whole, then, it looked as if the squatter had won: and the compromise which legislators tried to arrange was based on giving the leaseholder half his run undisturbed for a term of years and throwing the rest open to farming occupation at once. But it soon became clear that the leaseholder was no longer the stumbling-block. He had suffered heavily from blackmail and from the necessity of raising money on any terms: he had been compelled to face droughts and fires when his credit was thus exhausted, and had become, as often as not, merely a manager for the bank to which his run was mortgaged. The districts, moreover, which were still held under lease in the nineties were as a rule unfitted for economical farming, and land that was fit for it was being sublet by the squatters themselves to farmers who took a share of the produce. The real obstacles to a profitable use of the soil were and are (*a*) the ownership, usually derived from early grants, of large fertile tracts in the coastal or foothill regions by men who cannot or will not create on them the farms and orchards for which their soil is so fit; (*b*) the difficulty of getting produce to market from such areas of rich soil as still belong to the Crown. With this second obstacle and the remedies for it we shall deal in Chapter VI.: the first can be overcome only by a policy, now being gradually introduced, of buying back the best of the estates and reselling them in small blocks to farmers and orchardists.

CHAPTER IV.—THE ABORIGINES.

(A. W. JOSE.)

When Governor Phillip began the work of settling white folk on the shores of Port Jackson, he found the country already occupied by about 3,000 aborigines, and calculated that at that rate there must be a million or so within the bounds of what was then New South Wales. He had, of course, no knowledge of the conditions under which they had to exist in the interior, and so probably much over-estimated their numbers; for the fact that 3,000 of them were clustered round a spot where fish and game were plentiful could not set a true standard for a semi-barren and badly-watered continent. It is now believed that at the time of European settlement the total number of "blackfellows" in Australia was about 150,000. By 1901 they had dwindled to about 40,000.

It is possible that their ancestors were a branch of the Dravidian race, which once spread over Eastern Asia, but is now confined to the southern Indian peninsula. If so they may have made their way along the Malay islands and crossed into Australia either by Torres Strait or across the Arafura Sea from Timor. Once on the continent, they scattered along three routes of distribution, one to and down the east coast, one to and down the west coast, and one straight across the centre into South Australia. Consequently we have in Australia, roughly speaking, the curious phenomenon of a single physically uniform race occupying an immense area with very small numbers, and yet divided into numerous tribes with distinct habits, religions (using the term in its vague sense), and languages. As might be expected, the tribes of the two coastal sections are the most advanced; those of the east coast, to which the New South Wales aborigines belong, have not several rather brutal customs practised by the central tribes, and have acquired belief in definite supernatural beings "who approach the ordinary primitive conception of gods" (Gregory), whereas the central tribes follow witchcraft and fetishism.

The Australian aboriginal is often scornfully spoken of as the most degraded of human beings. This idea is wholly wrong. His ancestors were isolated in a poorly watered continent thousands of years ago; and Australia, with its few mammals and its uncertain rainfall, was not the place to suggest either pastoral or agricultural development. Thus the aboriginal had to maintain existence without either of these aids; his animal food must be hunted, his vegetable food must be discovered where it happened to grow. Given these conditions, the blackfellow has developed a surprisingly intricate and effective social system. His marriage laws, his tribal arrangements, his political methods, even his many languages (and he has plenty: in one district less than 300 miles square seven are spoken, one of them in two dialects and one in five), have been all gradually devised with an eye to lessening the difficulty of procuring food. Similarly the too frequent quarrels between the aborigines and the early white settlers nearly always began with trouble about food supplies: the tribe that had, according to its oldest traditions, the right of hunting over a certain district could not understand why it should lose that right because the newcomers had introduced some new animals, and went on hunting cattle and sheep just as it had previously hunted kangaroos. Then the settler called them thieves and savages without respect for property—though, as a matter of fact, he himself was violating their ideas about property by settling on their hunting-grounds. When, however, these ideas were respected, the tribes became orderly and friendly, and Europeans have lived among them and have been admitted to their intimacy.

A few quotations from a recent authority (Dr. Ramsay Smith, in the Official Year-book of the Commonwealth for 1909) will give a truer idea of the aborigines than most text books convey:—

> "Hunting, in the case of the aboriginal, is observation brought to a fine art and acted upon."
>
> "The variety of food is enormous, both from necessity and from choice. . . . The native lives well: he is more of an epicure than a gourmand. . . . . One is struck with the very extensive knowledge displayed by the aboriginal in his methods of preparing and cooking food. Cooking is certainly a fine art: among the processes employed are broiling, roasting, grilling, baking, steaming, and sometimes boiling."
>
> "The rules or conditions of fights appear to be as definite as those of civilized tournaments or duels."
>
> "Property in land is clearly recognized, and the limits of each tribe's country are accurately defined."
>
> "Childhood as a rule is a happy time. The blacks are fond of their children, and seldom beat or correct them. There are many games and amusements for them."

The aborigines are rapidly decreasing in numbers within the State bounds, and those who live there are more or less civilized. In 1901 the pure-blooded aborigines numbered under 4,000; in 1907 they were under 2,500; during that year there were among them 51 births and 111 deaths. This is not due to any neglect on the part of the State Government, which has reserved for them more than 25,000 acres, and looks after those who like to come in in nine settlements. These, which used to be mere camping grounds near which the blacks could get work to provide themselves with rations, are now carefully managed hamlets with good huts for married couples and good teaching for the children. But the blackfellow under civilized restraints seems bound to disappear, or to merge as a half-caste in the white population. The three huge States of the Commonwealth have room to accommodate him and his own social fabric; in New South Wales and Victoria he will soon be only an isolated curiosity.

PART II.—PHYSICAL GEOGRAPHY.

Chapter V.—MOUNTAINS.

(W. G. Woolnough, D.Sc., F.G.S.)

These positive land forms may be divided into several groups, *e.g.*, **fold** mountains, **block** mountains, **residual** mountains, **volcanic** mountains, etc.

Fold mountains have been caused by the crumpling of the earth's crust probably owing to gradual cooling and consequent contraction. The surface becomes thrown into great ridges and troughs as a result of the bending of huge masses of solid rock. The ridges are called **anticlines** and the troughs **synclines**. Where only one side of a fold has been developed it is called a **monocline**. (Fig. 17, p. 56.)

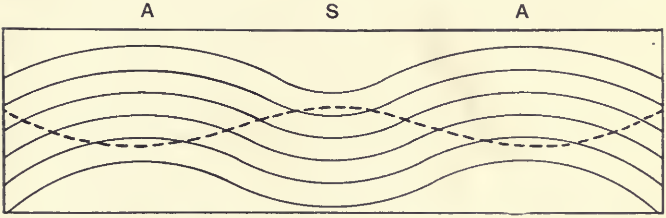


Fig. 11. Denudation of a series of folded rocks tends to reduce the anticlines (A) to form valleys, leaving the synclines (S) as ridges, as indicated by the broken line in the figure.

In the earlier stages of the history of fold mountains the anticlines form the hills and the synclines the valleys, but as denudation proceeds both synclines and anticlines are worn down also. The rocks at the crests of the anticlines are in a state of tension while those at the trough of synclines are compressed and therefore inherently stronger. Since the "dip" of the rocks in an anticline is **away** from the centre there is a great

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tendency for blocks to slip away from the crest as the lower portions (where the streams run at the beginning) become worn away. (See Fig 11). An anticline is, therefore, a weak structure. The material from the anticline tends to accumulate in the syncline which is thus to some extent protected from denudation. The syncline is obviously, too, an inherently strong structure. As denudation proceeds there is, then, a tendency for the anticline to be denuded more rapidly than the syncline, so that in course of time the **valleys** tend to occupy the **anticlinal** areas and the **ridges** the **synclinal** areas. Most of the **great** mountain chains of the world like the Alps and Himalayas are fold mountains.

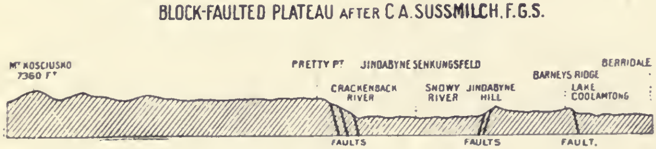

Fig. 12. Faulted plateau, Kosciusko to Cooma (after Süssmilch).

At times the forces producing the crumpling are so intense that the rocks give way under the strain and snap. Usually the areas on opposite sides of the crack move in relation to one another, and a geological **fault** is produced. Faults of this kind are common amongst fold mountains. Sometimes in the differential movements of blocks of the earth's crust affected by series of intersecting faults the blocks become tilted. This results in areas with long gentle slopes on the one side and short precipitous **scarps** on the other. Structures produced in this way are known as **block mountains.** Fig. 12.

When an area of land has become elevated above sea-level the streams at once commence to wear it down and dissect it more or less completely. The area is cut up into isolated blocks and ridges lying between the stream courses, and these blocks become smaller and smaller in area, and therefore more and more peak-like as denudation progresses. Mountains formed in this way are called **residual mountains** or **mountains of circumdenudation.** In a folded area, as we have seen above, the synclines tend to take this form. In level bedded strata, composed of alternating hard and soft beds, downward cutting by streams is very powerful owing to the wearing away of the soft beds and consequent undermining of the hard ones. In such a country the residual mountains are very irregular in outline, and tend to be terraced. (Fig. 15). Where a series of hard and soft beds is tilted in one direction, denudation tends to produce a parallel series of ridges, each with one gentle slope and one steep scarp, alternating with valleys, owing to the removal of the softer beds. (Fig. 15).

Mountains ranges are rarely referable to a single one of the above types; they owe their forms, usually, to a combination of forces, which, acting separately, would tend to produce mountains of one of the types described, and all we can say is that they are **dominantly** fold or block, or residual or volcanic mountains.

Mountains of New South Wales.—A glance at the map shows that the mountains of New South Wales form three chief groups:—(1) The so-called Main Dividing Range running more or less parallel with the coast; (2) the small group of the Warrumbungle Mountains. lying within the bend of the upper Castlereagh between Dubbo and Narrabri; (3) the Barrier Ranges in the extreme west of the State.

(1) **The Main Dividing Range.**—The relief map (frontispiece) shows that the Main Dividing Range is not a range of mountains in the ordinary acceptance of the term, that is, it is not a relatively narrow, sharp crested ridge. It is rather a broad plateau extending throughout the length of the country more or less parallel to the coast line. For this reason it is referred to in other parts of this book as the Main Divide. It is divisible into three fairly well defined portions, (i.) a southern section extending from the Victorian Border to the Blue Mountain Plateau; (ii.) a central section consisting of the horseshoe of the northern Blue Mountains and the Liverpool Range; (iii.) a northern section including the great New England Plateau. The highest peaks in Australia are in the Muniong Range, but the New England Plateau is the largest positive geographical feature of New South Wales, as far as mass is concerned. Throughout its whole length the Main Dividing Range is dominated by peneplain structure, and it is therefore considered in Chapter VI.

The Barrier Ranges are of a type quite different from either of the Main Dividing Range or the Warrumbungle Mountains. They are examples of a much denuded and partially buried range of fold mountains.

They consist of a series of parallel ranges rising to an average elevation of about 1,500 feet above sea-level and about 800 feet above the surrounding plains. The axes of these ranges trend about N.E. and S.W. They are built up of intensely folded and very ancient rocks (possibly including some of the most ancient rocks in Australia if not in the world) and are structurally closely related to the Mount Lofty, Barossa and Flinders Ranges of South Australia.

For thousands of centuries they have been exposed to the forces of denudation, during a great part of the time under conditions of desert weathering. They have been deeply denuded and are now almost buried in dreary plains of their own waste. In such a desolate setting has nature placed one of her richest treasures—Broken Hill.

Isolated peaks of ancient rock such as Mt. Brown represent the higher peaks of the northerly continuation of the Barrier Ranges, which have kept their heads above the level of the ruin surrounding them.

Between the Barrier Ranges and the western foothills of the Main Divide there occur numerous isolated hills of low altitude rising out of the plains. These hills are composed of rocks of the older geological formations, and represent merely the few remnants of a once extensive series of ranges almost completely overwhelmed by formations of comparatively recent origin. By comparison with the monotonous level of the surrounding plains very inconspicuous elevations are magnified into mountains. Many of these submerged peaks are metalliferous. *e.g.*, at Cobar, Nymagee, Mount Boppy, etc., and this fact suggests that stores of mineral wealth lie hidden below the surface.

The great mass of the **Warrumbungle Mountains** owe their origin primarily to volcanic action, though their remarkable contours are the work of denudation. They are described therefore in Chapter VII.

To the east of the Divide, rising from the coastal plains, there occur great isolated peaks or groups of peaks like Mt. Warning (on the Tweed) Anderson's

Sugarloaf (on the Macleay), Warrawalong (near Lake Macquarie), The Dromedary (near Tilba), and Mumbilla (near Bega); but these represent merely isolated portions of the great plateau and are treated therefore in Chapter VI.

CHAPTER VI.—PLAINS AND PLATEAUX.

(W. G. WOOLNOUGH, D.Sc., F.G.S.)

A **plain** may be defined as an approximately level, or gently undulating, stretch of country, at no great height, usually not exceeding 1,000 feet above sea level. A **plateau** is simply a plain at a higher altitude.

There is no well-defined altitude at which a plain can be said to pass into a plateau. Plains and plateaux may therefore be considered together.

Rock material tends to gather in broad, flat sheets below the waters of the ocean and of lakes. It accumulates also in the valleys of rivers. If any such accumulations become dry land we have one type of plain, called **Plains of Accumulation.** Two different classes may be distinguished, those formed of marine sediment, and those formed of sediment deposited on land. The former are called **plains of marine accumulation**: the latter **plains of subaerial accumulation.**

As an example of such plains of accumulation may be mentioned the deltas of our northern rivers from the Hunter to the Tweed. They are especially marked in the "Lakes District." As pointed out in Chapter VIII., they were formed chiefly by accumulations of river-borne sand and silt, but a slight elevation of the coast has been an important factor in their development.

The action of the wearing agents of nature is to lower the surface of the land gradually. This process is called **erosion** or **denudation**. At first, hard rocks are left standing while softer ones are worn away; but, if sufficient time is allowed, hard and soft rocks alike are removed. Running water is the most important agent in this process. It continues to act so long as it has sufficient velocity of flow, that is, so long as it has enough "fall." Its downward force continues to a level, or rather a gently inclined surface, sloping gradually upwards from a point a little below sea-level near the coast to a low altitude inland. This surface is called **base level**, and it is very important to have the conception of this term firmly fixed in one's mind.

It takes a very long time for the streams of a region to work all over it, and so reduce it to base level, but when this is accomplished, the area becomes a gently sloping plain almost at sea-level. Such an area may be termed a **plain of subaërial denudation** or a **peneplain**.

Wave action on a sea coast ceases at a moderate depth below sea-level, but, in the zone where it is active, it cuts the rock material away, and so forms a kind of shelf below water level. Given a long time for the work to go on, the shelf becomes very large. If it be elevated above sea-level, it gives us a fourth type of plain, namely, a **plain of marine denudation**.

Still another type of plain may be mentioned. In time past huge flows of lava have flowed over the face of the land, flooding the valleys, and even covering the hill-tops. A plain formed thus may be styled a **volcanic plain.**

If a plain is lifted high above sea-level by movements of the earth's crust it becomes a plateau.

A great deal of the surface of New South Wales consists of plains and plateaux. If a relief map (that is, a solid model showing hills and valleys) be prepared, this fact becomes very obvious. The photograph (frontispiece) is a picture of such a map.

The **Western Plains**, occupying a vast area in the western portion of the State rank first in extent and importance. The flatness of the land is almost inconceivable to a person who has lived all his life in ordinary undulating or hilly country. These plains are not quite horizontal, but have an extremely gradual slope, amounting, on an average, to but 18 inches in a mile, from the bed of the Darling River eastwards towards the Main Divide, and westwards towards the South Australian border. For hundreds of miles in this region there is not a vestige of rock, in the ordinary sense of the term; the surface consists of rich red or black soil of great depth. This soil contains a large amount of sodium chloride (common salt) and gypsum, the two salts most abundant in sea water. It shows every evidence of having been deposited in a shallow inland sea or salt marsh, which, at one time, occupied much of the area now taken up by western New South Wales, eastern South Australia and western Queensland. This Plain is therefore one of accumulation. Here and there as at Cobar, Mt. Boppy, Barrier Ranges, Mount Brown, etc., there rise through the silts small and large projections of very ancient rocks. Eastward and westward these patches of ancient rock become more numerous and larger, as we approach the mountains. Another interruption in the continuity of the plains is caused by the huge mass of the Warrumbungle Mountains; these represent the denuded stumps of a series of mighty volcanoes which broke into eruption near the shores of the old sea, not long before it finally became silted up.

That portion of the plains which fringes the high lands belongs to the type of earth structure known as a **Piedmont Plain.***

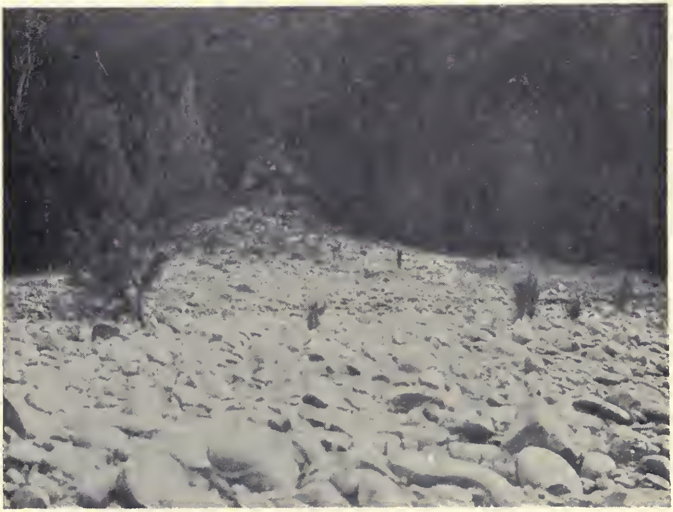

Fig. 13. Alluvial fan at mouth of a tributary gully, Shoalhaven River, Tallong N.S.W.

A stream rushing along mountain gorges is able to carry great loads of gravel, sand and mud. When it reaches the plains, its velocity is checked, and it deposits most of its load in the form of a flat cone with its apex at the opening of the gorge. Such an **alluvial fan** on a small scale is shown in the photograph Fig. 13. As the fan grows and spreads it meets neighbouring fans, and thus a continuous alluvial belt is formed. Where the mountains are high and the streams consequently rapid the cones remain fairly convex and more or less distinct; but when denudation has softened down the mountain contours and the streams have become more sluggish, the convexity and individuality of the cones ceases to be apparent, and their angle of slope becomes inappreciable. But while this convexity cannot be detected by casual observation, it is nevertheless present, and causes considerable instability in the river channels. In time of flood these very readily abandon their old course for quite new ones, as did the Namoi at Narrabri in January, 1910.

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* The name is derived from the French Pied-mont, meaning, literally, the foot of the mountain, and is applied to plains found in such positions, *e.g.*: the district of Piedmont, the plain in Italy at the foot of the Alps.

The black soil plains of western New South Wales lie mostly within the Piedmont Belt. Such black soil areas as exist further west being of the nature of flood plains adjacent to the channels of the larger rivers. The red-soils stretch out across the entire Plains Area.

As the rivers flow over these level expanses they lose their water partly by the very heavy evaporation and partly by soakage into the porous soil, so that they dwindle to insignificant streams, and many of them die out altogether.

Other plains also exist whose extent is far smaller than that of those just described, but whose scientific interest is very great. These, or rather their dissected remains, are met with throughout the whole of the Eastern Highlands where they rise tier above tier to altitudes of upwards of 7,000 feet. Most of these plains are of the nature of peneplains. Now, returning to the definition of a peneplain, we find that it represents a land surface which, after a long period of denudation, has been planed down to a fairly flat surface. The lowering of the surface goes on till base-level is reached. Locally a base-level may be determined by a lake, but such a type is neither common nor permanent. In practically all cases the base-level of a peneplain is about sea-level. In the case under consideration sea-level has certainly been the base-level. We are thus led to a very important conclusion. If we have a series of peneplains at different altitudes, each one of which was originally reduced to the same base-level, then there must have been a corresponding series of uplifts of the land, one for each peneplain, so as to form this series of terraces. The most elevated peneplain consists of a number of isolated points all rising to the same level, and standing upon a broader surface of the peneplain next below, which is itself not a continuous surface, but stands on a platform formed by the peneplain below it. (Fig. 14.)

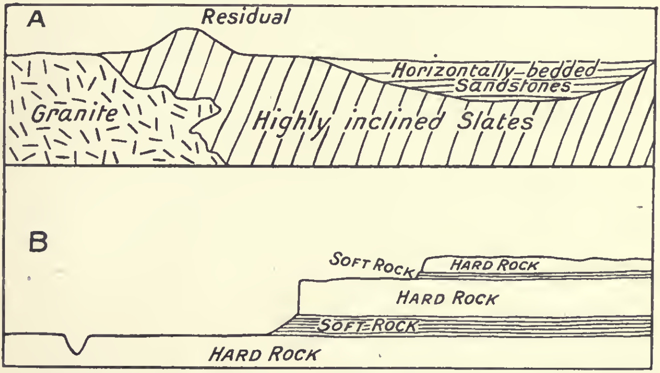

Fig. 14. A. Peneplanation reduces the land surface to one general level almost unaffected by geological structure. Residuals of older peneplains may be left standing above the general level.

B. "Benching" in horizontally disposed, alternately hard and soft rock layers.

The mechanism of this structure needs some explanation. If a plain of any kind is uplifted above sea-level the streams flowing from its surface have their "fall" increased and therefore their erosive power augmented. They cut valleys in the surface of the uplifted plain which thus becomes "dissected" and is converted into a number of more or less isolated, flat-topped hills ("mesas" or "buttes" according to size). As denudation proceeds, the intervening valleys increase in size at the expense of the "residual" hills, and increase also in depth, till base-level is reached. Downward motion being then stopped, the streams work laterally, forming wide base-levelled valleys, and still further reducing the size of the residuals. Finally a new peneplain is produced by the almost complete removal of the high ground and its reduction to base-level, and from its surface rise "residuals" of the older peneplain. It is important to notice that the difference in altitude of the two peneplains is equal to the amount of uplift which took place.

If a second uplift now occurs, the process above described will be repeated. **Both** of the older peneplains will suffer erosion, so that the residuals of the first may to a great extent disappear, and eventually a third peneplain will be thus produced at the new base-level.

Each period beginning with an uplift and ending with the succeeding base-level of the region is termed a **cycle of erosion.**

The following conclusions are important:—

i. Of a series of peneplains,* any one is older than those below it.

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*Authorities differ as to the amount of base-levelling necessary to constitute a peneplain. A cycle of erosion may be interrupted at any point; denudation may have reduced the whole surface practically to base level, or may have succeeded in cutting down completely only a very limited area, leaving the rest as a wide U-shaped valley bounded by definite ridges. By one authority the second structure will be referred to as a "mature valley," by another as a "partial peneplain."

ii. The difference in altitude of the residuals of successive peneplains is equal to the amount of elevation which closed the preceding cycle of erosion.

iii. The older a peneplain, the fewer and smaller are its residuals, as a rule.

Two other structures have to be distinguished carefully from those due to simple base-levelling.

If we have an area composed of horizontal rock beds, with a soft, readily eroded layer sandwiched between two hard resistant ones, or even an area formed of a very hard layer covered by softer strata, there is a tendency for the top beds to be stripped off, completely or partially, from the lower hard layer. This produces a level shelf or "bench" which may closely resemble a portion of a peneplain. The phenomenon is spoken of as **benching**. (Fig. 15). In the case of a true peneplain the surface is practically independent of rock structure.

The second structure which closely resembles peneplains at different levels is caused by faulting. Great earth cracks often form, and the land on one or both sides of the crack moves up or down. An originally continuous level surface may thus be split up into two or more levels which are likely to be confounded with peneplains. Such areas bodily uplifted or dropped are spoken of as **fault blocks** (Fig. 12; compare also p. 38).

Our knowledge of the various peneplain and valley levels in the mountains of New South Wales is still far from complete.

It has been shown by E. C. Andrews that throughout eastern Australia, from the north of Queensland to

Govt. Tourist Bureau.

Tasmania, the evidence supplied by peneplain and valley levels points to the whole continental strip having risen and sunk as a unit. That is to say, a peneplain has formed at all parts at the same period, and uplift has affected the whole area at once. The uplift has not been uniform throughout; some parts have been lifted to heights of over 7,000 feet, others to not more than about half that height. Minor movements have affected different sections of the plateau in various ways, so that in the County of Cumberland, for instance, the plain at Sydney lies almost at sea-level, while 24 miles to the south and north it rises to 733 and 702 feet respectively. On the west at Glenbrook, there is a sudden bend or buckle in the surface of the plain involving a difference of level of over 500 feet within a couple of miles. (See also p. 56). In spite of these local variations, however, the general unity of structure along the whole eastern coast has been preserved.

In the **New England District** the plateau character is very marked, and several distinct levels can be made out. Each of these spreads out as a wide gently undulating upland plain, over which the river valleys wind with every appearance of maturity of development. Thriving towns and settlements are scattered over the plain, and but for the light pure air, one can scarcely believe himself to be on mountain tops, over 4,000 feet above the sea. The break from level to level is always fairly sharply defined.

The general slope of the larger and more continuous sections of the plateau is toward the west, yet great areas of them are drained by rivers belonging to the coastal system. The Main Divide is therefore lower than the mountains between it and the coast. The cause of this will be explained in the chapter on "Rivers" (p. 85). The streams, after wandering in broad open valleys on the uplands, suddenly plunge over great precipices into the depths of profound gorges, as at the Wollomombi, Apsley, Tia and other Falls. For long distances the river channels remain as deep cañons until they open out on to the coastal plain. This characteristic is exhibited by the branches of all the rivers of the region; so that, while the western strip of the plateau is comparatively level, its eastern border is so completely dissected by a network of gullies and gorges as to be an almost impenetrable maze of mountains formed by denudation. It is certain that most of these levels are formed of fault blocks, and are not due to different cycles of erosion. The different levels originally called by Andrews, Mole Tableland, Bolivia Plain, Stannifer Plain, and so on, are now regarded simply as faulted portions of a much smaller number of peneplains, or even of one peneplain whose surface is dissected by highly mature valleys. The railway section from Werris Creek to Wallangarra illustrates this **block mountain** arrangement very well, though it is doubtful to what extent these differences of level are due to faulting on the one hand, or differential erosion on the other.

As is stated in the chapter on Rivers, the **general** slope of the uplands is from east to west, and it is a significant fact that the highest points lie on the eastern side of the Main Divide. This eastern escarpment of the New England Range is a most stupendous scenic feature. At points like the Snowies, near Guy Fawkes (over 5,000 feet in height), and Mount Sea

View, one looks down to low-lying plains almost at one's very feet and across them to the Pacific. This scarp is largely defined, no doubt, by lines of faulting, but is due also in no inconsiderable degree to the erosive power of the rivers. Particularly in the extreme north-east of the State the plateau has been very maturely dissected by the waters of the Tweed, Richmond and Clarence Rivers, and the valleys have been reduced almost to sea-level. The remnants of the peneplain stand up as continuous ranges like the Macpherson Range, Richmond Range and others; while isolated peaks like the glorious summits of Mounts Warning and Lindsay have been left standing at almost their original heights on account of the intense hardness of the volcanic rocks of which they are composed. Anderson's Sugarloaf, on the Macleay River, and the Gloucester Buckets are similar isolated peaks. Further inland, about the heads of rivers like the Nymboida and Macleay, we have an impenetrable maze of ridges and gorges representing deep, but incomplete, dissection of the plateau by stream action. The few roads leading from highland to coast are splendid engineering feats, and abound in scenery of the most rugged type.

In the **Blue Mountain area**, also, different levels are recognizable; but, as in New England, some of these may be fault-blocks; for example, Sunny Corner in all probability. Others may be due to benching, since the horizontal distribution of the strata and their very varying hardness are eminently adapted for the production of this type of structure.

Standing on some slight eminence in the Blue Mountains the landscape appears as a monotonous level plain, and one can scarcely conceive that he is almost on the brink of a vertical-walled cañon nearly 2,000 feet in depth. The suddenness with which a tourist comes upon the most mighty panorama is by no means the least important of its attractions.

As Carne* very truly remarks:—

"Not in impressive heights but in profound depths lies the chief charm of Blue Mountain Scenery. Magnificent canyons and precipitous ravines break the monotony of a summit but faintly relieved by solitary masses above the general level of erosion, which owe their preservation to protective basalt coverings......

"Mountain topography, cursorily scanned, is deceptive as to heights and distances. Great intervening depths magnify altitudes in isolated mountain masses. The prominent summits of Mounts Banks (or King George) and Tomah, viewed from the plateau level at Blackheath or Mount Victoria, across the magnificent valley of the Grose (over two thousand four hundred feet in depth) appear to rise above, though actually beneath, that plane."

These great depths are the work of rivers flowing over the plateau since its elevation from base-level. Most tourists find this statement almost inconceivable. The insignificant trickles flowing over many of the Blue Mountain waterfalls seem ludicrously inadequate to account for the tremendous chasms below. It must be remembered, however, that we have "happened on" the area just when erosion has almost completely dissected it. Formerly, when much of the plateau remained undissected, these streams had much larger watersheds and were therefore of much more considerable dimensions, so that instead of streams like those above Govett's Leap, heading only a mile or two from the cliffs, there were streams comparable in size with the main waters of the Grose and Capertee at work dissecting the area.

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*Carne, J. E., Geology and Mineral Resources of the Western Coalfield. Memoir No. 6, Geol. Surv. N.S. Wales, 1908, p. 11.

Another point to be remembered is that, in spite of the massiveness of the sandstones forming the cliffs, the entire geological structure is an extremely weak one. "The head may be of gold and the body of brass, but the feet are of clay." Between the two great masses of sandstone there is a thin, but extremely persistent band of chocolate shale which weathers readily, and so undercuts the upper sandstone. This latter is traversed by continuous vertical "joints," and so, when

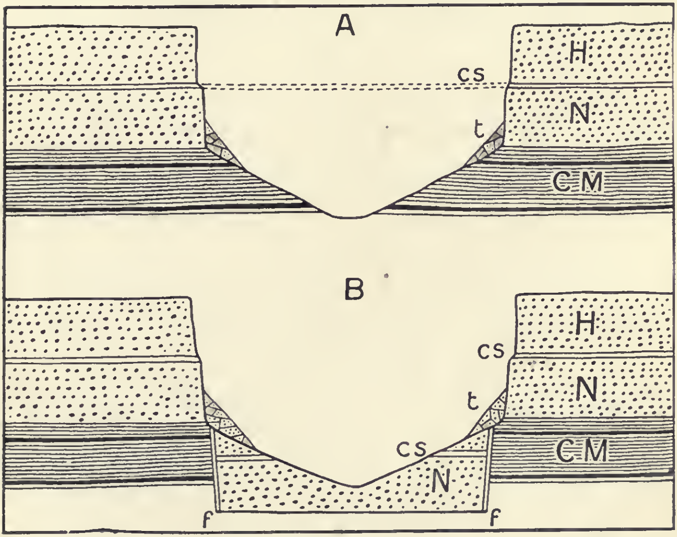

Fig. 16. Two possible explanations of the formation of a Blue Mountain Valley. A represents the correct one.
H = Hawkesbury sandstone. C S = Chocolate shale. N = Narrabeen sandstone. C M = Coal Measures. t = talus.

undermined, falls away in huge blocks, leaving a clean perpendicular cliff face. (Fig. 16). The "benching" due to this process is very distinct in most of the mountain valleys.

Below the lower sandstone we have the soft shales and coals of the Coal Measures, which are even less stable than the chocolate shales. As soon as the valley bottom reaches these rocks, both deepening and widening are comparatively rapid. The solid sandstones account for the vertical cliffs, but the soft shales below cannot stand at such steep angles, hence the characteristic slope to the valley floor from the cliff base.

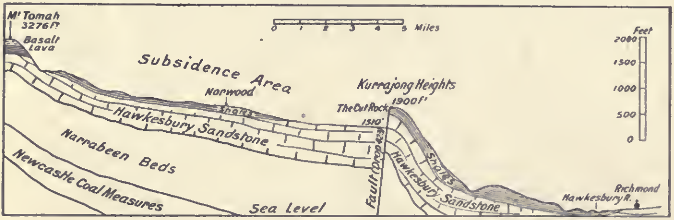

Fig. 17. Section from Mt. Tomah to Richmond (after David).

The general slope of the plateau is eastwards, from 3,500 feet at Bell to 599 feet at Glenbrook, a distance of 26 miles. At Glenbrook the sudden change in level above referred to (p. 51) occurs. It is due to a warping down of the coastal strip along an axis nearly north and south (Fig. 17). Further north, at Kurrajong Heights, on the western side of this fold, there is an important fault running parallel with the fold, and letting down the plateau behind it. (Fig. 17). The effect of these two structures combined is to produce the remarkable ridge of the Kurrajong. The depression of the coastal plain probably reaches its maximum at Sydney, for, as already noted, its altitude increases both north and south. In addition to the north and south folding and faulting, a certain amount of east and west cracking has occurred also. Parramatta River has had its course defined by such a fault. which has let down its southern shore to the extent of at least 100 feet as compared with the northern bank.

As explained in Chapter X. (p. 128) it is to the dissection of the plateau by streams and its subsequent depression that we owe the magnificent inlets on our coast.

In the south of New South Wales the plateaux reach their maximum elevation at Kosciusko, 7,300 feet above sea level, and the highest point in Australia. While the formation of one or more peneplains is the fundamental process here, as throughout the highlands of New South Wales, the complications introduced by block faulting are much more extensive than elsewhere.*

As explained in Chapter VIII., this faulting has been so recent as to have very profoundly modified river development. Most of the so-called ranges, such as the Monaro, Gourock, Cullarin, etc., are really the steep sides of such fault blocks, rendered conspicuous by the dropping in of the block forming the adjacent "valley." The economic importance of such ranges must be appreciated; for instance, the occurrence of one of them has necessitated heavy tunnelling on the railway line near Queanbeyan. The great scarp facing the plains of the Bega River is another example.

As Andrews has pointed out,† block faulting resulting in high mountain summits reaches its maximum in the neighbourhood of Mount Kosciusko, that is, just where the trend of the lines of earth weakness expressed by the highlands changes from a general north and south line in New South Wales to a general east and west line in Victoria, and great complexity of physiographic features is introduced in consequence.

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*Sussmilch, C. A., Jour. and Proc. Royal Soc. of N.S. Wales, Vol. xliv., 1910.

†Andrews, E. C., The Geological Unity of Eastern Australia, Jour. and Proc. Roy. Soc. N.S. Wales, Vol. xliv., 1910.

A further element of variety is added to the scenery in this district by the characteristic forms given to hill and valley owing to denudation by ice sheets, which have resulted in the production of lakes, (Chap. IX.) hanging valleys (Chap. IX.), and other features absent to a great extent in areas where river action alone has been responsible for the relief of the surface.

Chapter VII.—VOLCANOES AND SOILS.

(T. G. Taylor, B.A., B.E., B.Sc.)

Although long ages have passed since any volcanic action occurred in the State, yet there are many reasons why this subject should be briefly discussed from a geographical point of view. The miner, the farmer, and the tourist are all indebted in some degree to the dead volcanoes. The flow of the basic lava along old water-courses has preserved the alluvial gold from subsequent distribution. At Gulgong and on many other gold-mining fields, these "deep leads," as the buried alluvial deposits are termed, have yielded large quantities of the precious metal, at Gulgong, for example, 13¼ tons in five years. (See Pittman, "Mineral Resources.")

At Corowa the basalt has filled in an old channel of the Murray, necessitating a shaft 300ft. deep to reach the level of the gold. The water collecting in these old river channels offers great opposition to profitable working and, as shown in Fig. 18, two "levels" are necessary to work the deposit, the lower one serving to drain the alluvial.

Many of the most striking features of the scenery of the State are due to the presence of volcanic centres. The rounded peaks to the north of Katoomba, **Mount Hay, Mount Tomah, Mount Wilson**, etc., are the relics of old basaltic flows from volcanic vents in the neighbourhood.

The most conspicuous hill between the Blue Mountains and Sydney, **Prospect Hill**, near the great reservoir, is an attempt at a volcano, the eruptive rocks probably not reaching the surface. (Fig. 19). Perhaps the largest excavation in the vicinity of Sydney is the huge "blue metal" quarry at Dundas, nearly 150 feet deep, representing the solid plug of a volcano; while similar, but smaller, masses of basalt are used for "metalling" the roads in many portions of New South Wales.

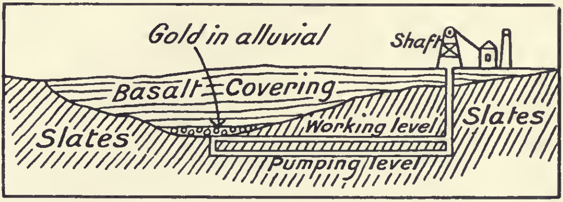

Fig 18. Cross section of deep auriferous lead on the Lower Murray near Corowa. (From Pittman.)

Many of our pronounced coastal features were determined by volcanic action of an indirect nature. The long narrow bays to the south-east of Sydney between Port Jackson and Botany Bay point generally in a west-north-west direction. This is the direction in which the "dykes" or intruded walls of basalt radiate from a hypothetical volcano out at sea. Indeed in many cases, as at Long Bay and Mirror Bay, the decomposing basalt dyke can still be seen at the head of the bay. At Bondi these dykes have weathered away, leaving huge clefts in the cliff, forming a point of entry for further coastal erosion.

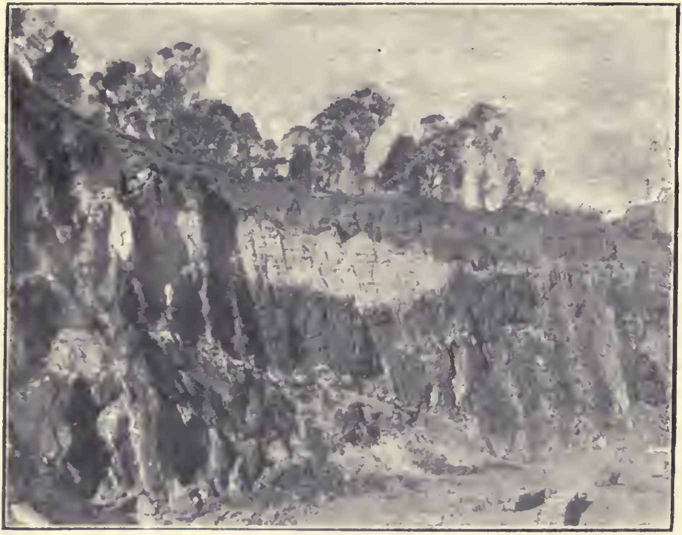

Fig. 19. Quarry face at Prospect.

On the other hand, where the basalt has resisted "weathering" it may serve as a buttress and preserve the softer sediments through which it has burst. Of this type is the dyke which has probably given rise to the projecting tongue north of Manly, known as **Long Reef**.

Many of the "basins" occurring along the courses of the Blue Mountain rivers are due to the rapid weathering of an old volcanic pipe, leading to the formation of a sort of amphitheatre, or broadening, in the river gorge. A good example occurs at **Norton's Basin**, ten miles above Penrith, on the Nepean River. Similar centres of rapid erosion occur at "The Valley," Springwood, and at the volcanic neck just west of Hornsby.

A description of one of these old volcanic "necks," that of **Dundas**,* will serve to illustrate the present condition of a Tertiary volcano. About five miles north-east of Parramatta, amid the undulating hills of weathered shale characteristic of the Sydney-Penrith area, a rounded knob of reddish rock contrasted strongly with the surrounding sediments. Within the last fifty years most of this "outcrop" has been removed, and a hole some 150 feet deep bears witness to the demand for "road metal." Fig. 20 shows a view of the hypothetical crater of this volcano in Tertiary times. Possibly it has been quiescent for a million

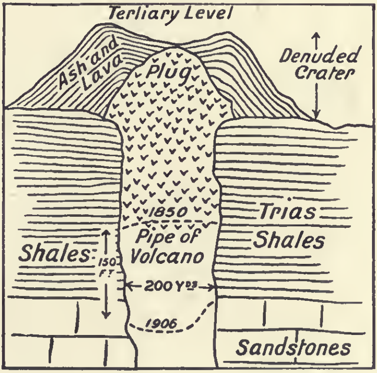

Fig. 20. Section of Dundas Quarry.

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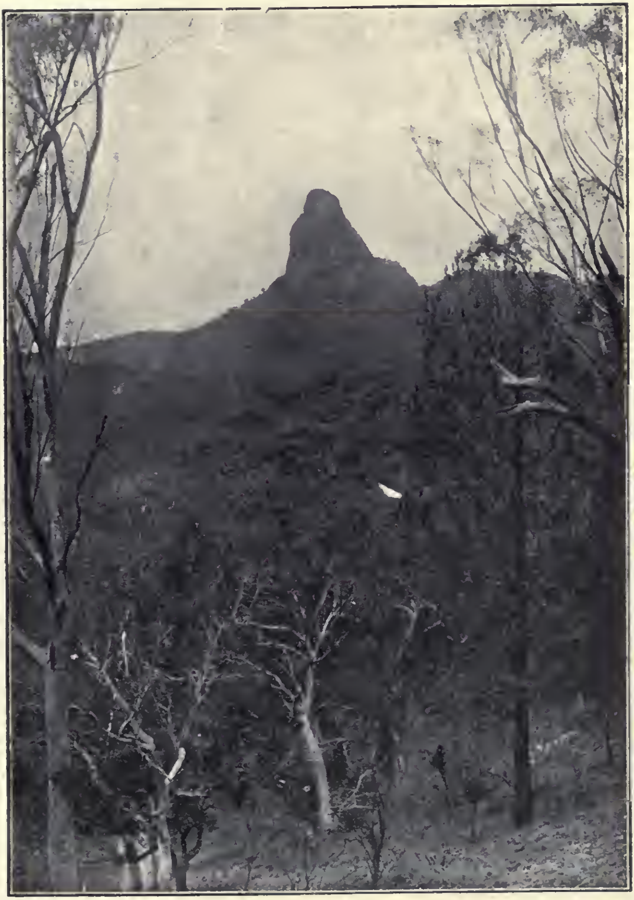
*For details see Journal Roy. Soc. N.S. Wales, Vol. XLIV., v. 495. By W. N. Benson, B.Sc.

years, since no sign of volcanic ash or scoriæ now remains, nor has any lava been preserved. Yet much of interest still remains, especially as it is possible to investigate over a hundred feet below the level of the old crater owing to the exertions of the quarrymen. On the east side we see where the walls have been cracked in two places, and the cracks filled with vertical sheets of basalt, now known as "dykes," several feet wide and of unknown length and depth. The surrounding shales show the intense baking due to the molten basalt, and are hardened to a substance resembling black flint. In many places can be seen fragments of the wall of the pipe, torn off and incorporated in the lava, giving rise to a volcanic agglomerate. Lastly the basalt seems to have carried up with it fragments of other deep-seated allied rocks of a rare type. These latter are especially interesting as they to some extent resemble the rock in which diamonds have been found in South Africa, though no evidence of these gems has been detected in our specimens.

Since the volcanic outbursts in New South Wales are much older than the beautifully-preserved series in Southern Australia, it is natural that here we find practically no remnants of the craters which once surmounted the pipe of the volcano. The most striking relics are the solidified plugs of these volcanic pipes. In the Warrumbungle and Nandewar Ranges, lying on the western flanks of the Main Divide, between the Castlereagh and Gwydir Rivers, there are many fine examples of these volcanic plugs (see Fig. 21). They are composed, however, of rocks containing much more silica than the basalt series, and are known as **Trachytes.**



Judge Docker.

Fig. 21. Tondeburine Spire—a residual plug of olivine trachyte in the extinct volcanoes of Warrumbungle Mountains.

Almost all volcanoes which have been active during recent geological periods, have emitted material of a **basic** nature, that is, rich in iron and lime, and poor in silica. When a lava flow occurs the rock formed usually resembles **basalt** in composition, which consists essentially of three minerals, a colourless lime silicate known as **felspar**, a dark brown mineral composed of iron, magnesia and silica, **augite**, and an oxide of iron or **magnetite**.

In past geological eras rocks rich in silica with potash and soda minerals were erupted, such as the lavas of Pokolbin, south of Maitland, and the trachytes of the Mittagong district; but all the extinct craters of Southern Australia, as Tower Hill and Mount Gambier, together with those flows in New South Wales which have been determined by the geologist to be the **latest** in the volcanic series, are formed of the dark rock, basalt, which, as will be shown later, usually gives rise to rich soils.

Turning now to the fundamental industry, **farming**, we may note the effect of the volcanic products in enriching the soil of the State. Merrill ("Soils," page 362) writes as follows:—"It seems to be now pretty well conceded that of all the constituents found in soil aside from moisture, only potash, lime, magnesia, phosphoric and sulphuric acids can be considered absolutely essential as plant food. . . . . Magnesia and sulphuric acid are almost invariably present in sufficient quantities, while **potash, lime,** and **phosphoric acid** are liable to exhaustion under ordinary methods of cultivation. The potash and lime must have come originally from the decomposition of felspar, mica, amphiboles" and allied minerals. "So small comparatively are these percentages, that it is rare, indeed, to find a soil which on complete analysis, will not be shown to contain them in sufficient proportion. The varying degrees of fertility in such cases are due then, not to differences in ultimate composition, but to difference in combination of those elements whereby they are or are not available for plant food. A **granitic** rock contains locked up in its mass all the mineral elements necessary for a fertile soil, but remains barren simply because these are in a condition of slight solubility, and its physical structure is such that even the soluble portions are unavailable." A **basalt,** though it contains less potash and more lime than is necessary, yet yields readily a fine reddish soil on weathering. **Sandstones** such as the Hawkesbury sandstones are composed chiefly of quartz (silica) grains derived from decomposed granite, and when unmixed with organic matter form very poor soils. **Shales** are more suitable physically for plant food. In many parts of New South Wales the shales owe much of their fertility to an admixture of volcanic ash or tuff.

	Granite	Granite Sand	Basalt	Decomposed Basalt	Hawkesbury Sandstone Soil
Silica	69·3	65·7	43·6	43·2	sand 23·1
Alumina ...	14·3	15·2	12·3	18·1	clay 69·5
Iron oxides ...	3·6	4·3	15.6	11·7	3·6
Lime	3·2	2·6	11·3	2·6	0·1
Magnesia ...	2·4	2·6	9·1	3·4	0·1
Soda	2·7	2·1	2·7	·3	0·07
Potash	2·6	2·0	·8		
Phosphoric acid ...	·1	·06	·8	...	0·03

In the above table analyses of granite and basalt are given with the soils resulting. The granite is seen to contain more potash and much less lime than the basalt,

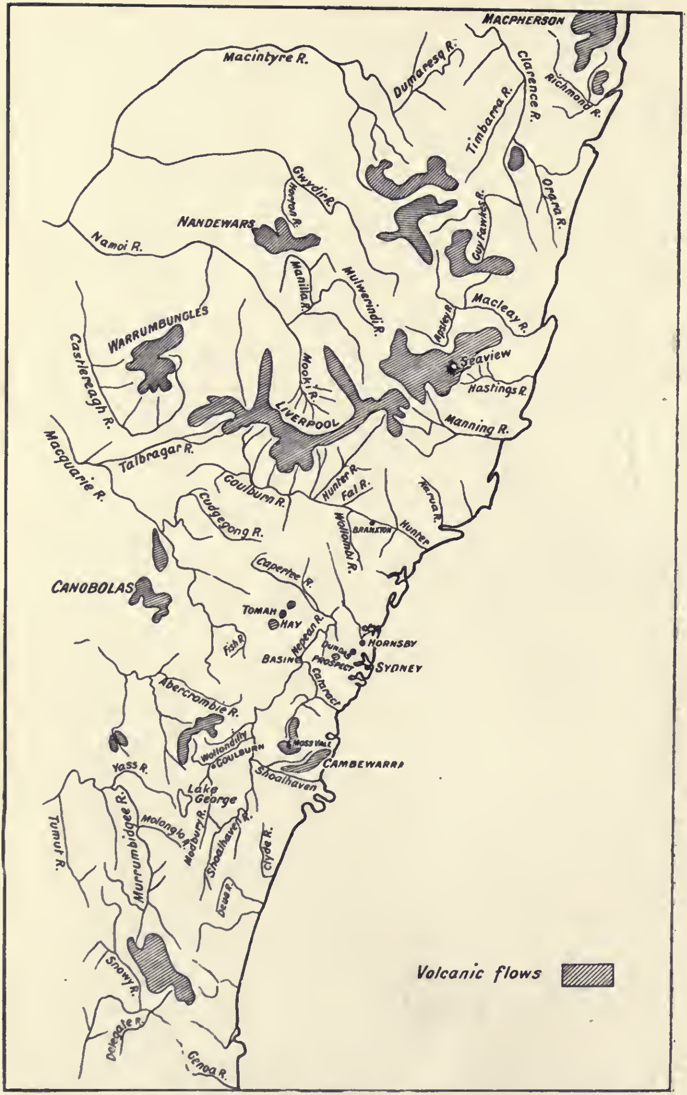


Fig. 22. Map of Volcanic flows, chiefly basalts with some trachytes. Drainage of Eastern New South Wales showing the interruptions due to Volcanic flows.

but the latter presents the salts to the plants in a more soluble form. The minerals of granite (orthoclase, quartz, etc.) do not break up with anything like the rapidity of the basalt minerals, (labradorite, augite, etc.), nor do they yield such finely divided soils as the latter type of rock.

The annexed sketch plan (Fig. 22) shows what large **areas** are covered by this basalt rock. The latter are usually the newest rocks in the district, *i.e.*, no sediments have been deposited over them, as the greater part of New South Wales has not been depressed below sea level since the close of the period of volcanic outburst. In many cases the best farm lands are situated on the tops of low hills. This is the case along the southern line from Campbelltown to Goulburn. When the volcanoes were active the lavas flowing from the crater in many cases ran along the lowest available ground, probably the beds of neighbouring creeks. Subsequent erosion and denudation result in the former creek bed, owing to its hard covering of basalt, standing out as a flat-topped ridge. Later still this ridge weathers to a rich reddish soil, which is the first area to be cleared and cultivated. Hence in many districts the old basalt lava flows can be distinguished as green cleared areas, surrounded by worthless scrub and rocky country where the surface rock is a sandstone.

The intimate relation between **soil** values and geological formations is engaging the attention of the Department of Agriculture. An interesting map from a report by Dr. H. I. Jensen (February, 1910) is sketched in Fig. 23. It will be seen that the good soils comprise the eruptive rocks **granite** and **basalt,** and the shales of the coal measures and later Trias period; but

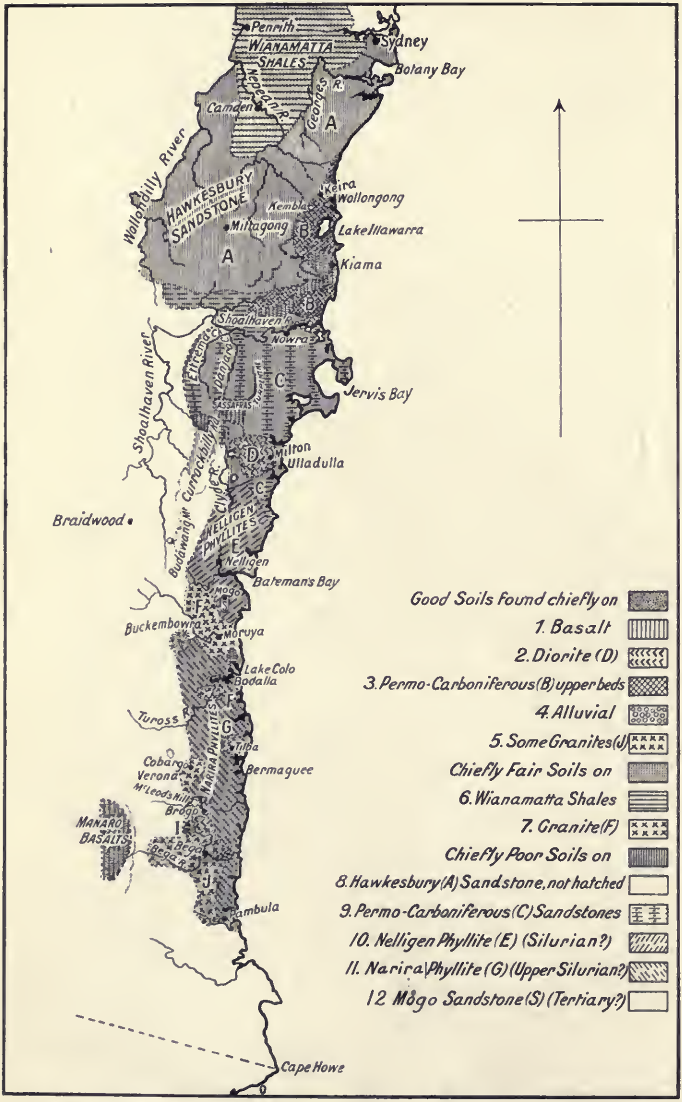


Fig. 23a Sketch map by H. J. Jensen, D.Sc., showing approximate extent of Type Soils and Geological Formations on the South Coast.

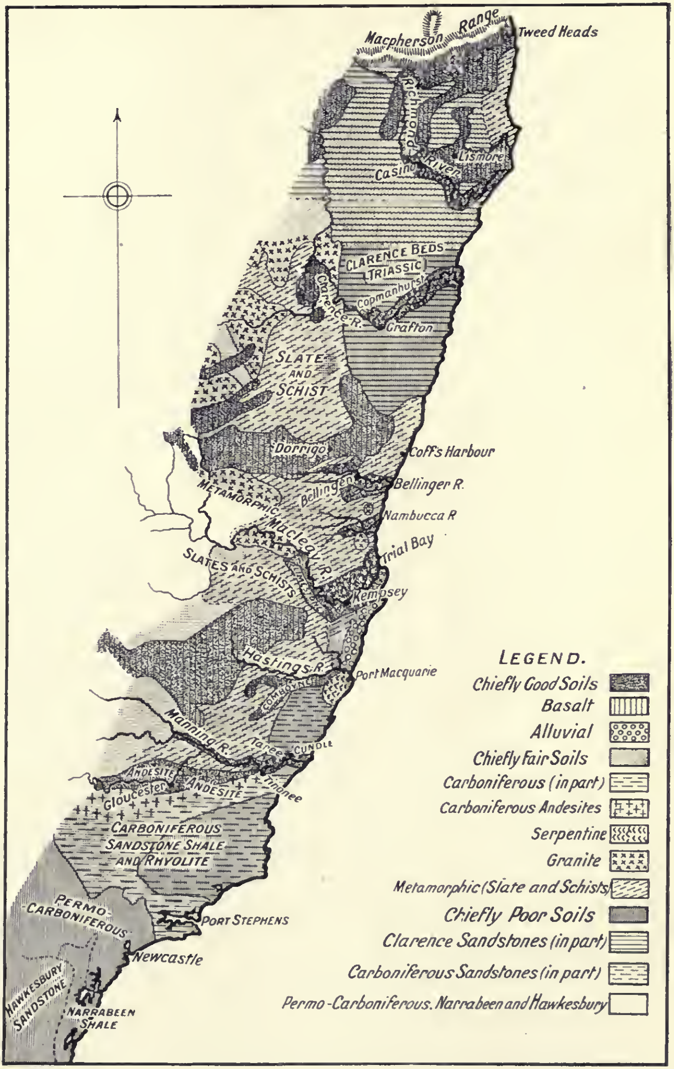


Fig. 23b Sketch map by H. J. Jensen, D.Sc., showing approximate extent of Type Soils and Geological Formations on the North Coast.

the sandstones and very old slaty sediments contain very little food suitable for crops, though fairly good timber grows on them.

Finally we may touch upon the relation between the **flow of the rivers** and the centres of volcanic eruption. An example of this will be dealt with in the chapter on Rivers, showing that the course of the Horton River had been altered, leading to a "palm-tree" type of drainage. Obviously this deflection proves that the original rivers existed before the volcanoes. The latter are known to be early **Tertiary**; therefore we have strong grounds for assuming that the rivers in this region date from late **Secondary** (Cretaceous) age. But there is another set of volcanoes of the same curious lava—a trachyte rich in soda—a little to the south-west of the Nandewars. These are the **Warrumbungle Mountains**, and the solidified plugs of these old volcanoes are extremely picturesque objects (see Fig. 21).

Their geology has been investigated by Dr. Jensen, and he shows that in early Tertiary times there was a concentration of lava beneath this area which actually bulged the crust of sediments upward. Then the crust gave way and numerous volcanoes arose as outlets of this subterranean reservoir. When the river drainage developed again, instead of the simple-branched system trending to the north-west—which is characteristic of the Bogan and Macquarie, we get the radial drainage of the Castlereagh, which reminds one somewhat of a closed fist.

Quite recently a little lake on the Great Divide near Guyra has been described* as occupying an old crater, with portions of its wall still existent. It is roughly oval with diameters of one and two miles, and is bounded by a rim 40 feet above the bed of the lagoon. This fairly continuous **rim** certainly seems to separate it from the numerous "warp" lakes which are characteristic of the new divide, and if so we have in New South Wales a humble rival of the beautiful craters of Tower Hill (Victoria) and Auckland (New Zealand).

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*L. A. Cotton, B.A., B.Sc., in Linn: Soc: N.S.W. 1909 p. 233. Those readers interested in the ancient volcanoes of New South Wales and Queensland will find the numerous papers by Dr. Jensen (in the same journal) full of interest.

CHAPTER VIII.—RIVERS.

(W. G. WOOLNOUGH, D.Sc., F.G.S.),
With notes by T. G. TAYLOR, B.E., B.Sc., B.A.

When a shower of rain falls upon a newly-formed roadway the water runs off in the direction of maximum slope. Little rills collect into larger runnels which unite into still larger streams, the whole forming a symmetrical branching arrangement like the twigs, branches and stem of a tree. (Fig. 24). It will be noticed that the roadway is cut into by these streams, the depths of the cuts being, at first, almost proportional to the sizes of the streams which make them. Thus a stream has **erosive power** in consequence of which it tends to deepen its valley vertically. The water running off is muddy, due to earth particles carried in suspension, hence the stream has **transporting power**. If there is a level stretch of ground beside the road bank, it will be noticed that each little stream deposits sand and mud upon it in the form of a broad fan; this shows that a stream has also the power of building up or aggrading the surface. If the embankment is not repaired, successive rain storms carry on the work commenced by the first one and our miniature valley develops by degrees. The "twigs" extend in length and the channels become deeper until the main channel reaches the level of the flat upon which the bank is built. Here increase in depth is arrested by lack of "fall" and the sides of the channel begin to be attacked most powerfully so that it commences to widen. Deposition of sand and mud, at first confined to the level beyond the bank, begins to take place within the valley, and, as time proceeds and the channel develops, this aggradation occurs farther and farther up stream. In the earliest stages the cross section of each streamlet is V shaped; when the level of the road formation is reached it becomes U shaped. (Fig. 25). Finally the whole embankment may have its surface lowered by removal of material, until only a few remnants are left standing slightly above the level of the road foundation,

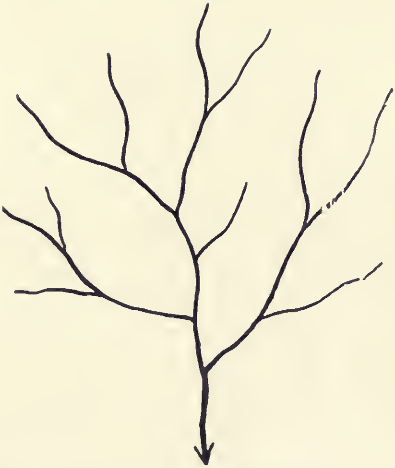

Fig. 24. Diagram of normally developed river system.

which, in this case, marks the downward limit of erosion.

A series of observations of this kind shows that a streamlet passes through a kind of life history. It comes into being by the building up (elevation) of the road bank; it passes through a youthful stage of development in which its activities are entirely destructive, so far as the bank is concerned; it becomes mature when its lower portions begin to deposit material within the limits of the road bank; and passes into old age and death when it has reduced the whole bank to the level of the foundation. Such a cycle of changes more or less modified by accidents of various kinds is typical of the life of streams of all dimensions.

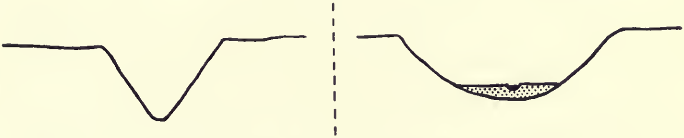

Fig. 25. A V-shaped young river valley, and a U-shaped mature river valley.

Several points must be observed. First there is a limit of downward cutting imposed by the reduction of "fall" of the water below the amount necessary to cause active removal of material. This is called "base level," and in the case of our "pocket edition" of a stream is the level of the ground on which the road is built. The grand base level of erosion is the sea, but temporary base levels may be imposed upon streams in a variety of ways, of which we shall have examples later.

In the second place different parts of a stream system may be in different conditions of "age" at the same time, the upstream portions being more youthful than those nearer the mouth.

While the use of these age terms is very convenient, experience shows that beginners often fall into misconceptions with regard to them. Many factors other than the **time** during which a stream has been in existence influence its degree of development. Other things being equal, a stream of great **volume** or steep **slope** will attain maturity before one not possessing these advantages. A stream flowing through soft material obviously has an advantage over one which traverses hard structures so that **geological formation** must be taken into consideration.

When a river has reached maturity of development and has removed all but a few hills in its valley, these outstanding high portions are called **monadnocks**.

With this brief preliminary sketch we may proceed to study the development of some of our New South Wales rivers, introducing definitions and explanations as may be necessary.

River Systems of New South Wales.

The rivers of New South Wales fall naturally into two groups, the **Western Rivers** and the **Coastal Rivers**. All the former are parts of one great system, and drain to the sea eventually through a single mouth. These rivers are for the most part long, gently sloping and slow flowing. The latter are relatively short, steep streams entering the Pacific Ocean by independent mouths. So far everything is simple, and one might be tempted to explain the facts as simply due to the development of a mountain range quite close to the eastern coast line. While this is the most important individual factor in producing the existing condition of affairs, when we come to study the details we find endless complications arising through mutual interference of the streams, earth folds and fractures, immense flows of lavas and other causes. The object of the following pages is to indicate briefly some of the most noteworthy facts which have as yet been proved. Many other fascinating problems await investigation, while some of those which have already been solved present too great complexity to be treated in a work of this kind.

Far away back in Geological Time, while the materials of the chalk cliffs of England were being formed as ooze on the sea bed, there existed a vast Mediterranean Sea occupying much of what is now the interior of Australia. On the east this was bounded by high land extending, in all probability considerably to the east of what is now the coast line. In consequence of a general slope to the west, rivers streamed down from the hills into the Western Sea carrying thither sand and silt which now seals down the artesian water in the Great Basin. Streams whose direction is a direct consequence of the general slope of the land are called **consequent streams.** As the land became reduced by river erosion to an undulating surface (a peneplain) at a low elevation, the streams naturally developed most extensively along the softer geological formations. Now the older geological formations have a strong north and south trend and there is an alternation of hard and soft belts; hence the very marked development of north and south streams the dismembered portions of which can still be recognised throughout the area occupied by the old high lands.

Later the cretaceous sea, as it is called, became shallowed by accumulation of sediment and the streams thrust forth deltas into it and thereby extended the lengths of their courses. Rivers which originally entered by separate mouths united as a result of the extension of the coastal plain and individual watersheds became engrafted into a smaller number of more extensive systems. A depression of the southern part of Australia accompanied by an uplift of northern Australia and New Guinea caused an encroachment of the sea at the south and a general tilt in that direction; and the streams formerly flowing north-west (the ancestors of the Upper Darling tributaries) became diverted towards the south. It is probable that the existence of this later (Tertiary) sea caused the development of the Murray system of streams (as distinct from the Darling system).

Silting and elevation have now completely ousted the sea from Central Australia, but the rivers brought into existence by its presence there have remained. Great extension of the process of **engrafting** mentioned above has gradually combined the whole of the Darling and Murray streams into one of the great river systems of the world. It is extremely doubtful whether any of the original consequent streams can be recognised; our present western rivers are, however, their lineal descendants.

Taking the Culgoa and Darling as a type of these western streams, it rises in the southern Queensland highlands (Fig. 26) and flows through rugged country for some distance. In this part of its course it presents the features of a young river. After flowing for 250 miles under these conditions it enters the plains at

St. George. From Brewarrina (400 feet) to Wentworth (250) feet, a distance of 400 miles, it winds through immense plains of silt of its own building. During floods the river overflows its banks and, as a result of slackened flow, deposits silt over the submerged areas. The heaviest deposit of silt is close to the normal banks, which, in this way become raised above the surrounding country, so that the river comes to flow along a kind of natural elevated aqueduct. This rather unstable condition of affairs is the cause of the development of "anabranches" or great "splits" in the river channel which may run about parallel with the main stream for scores of miles before rejoining it.

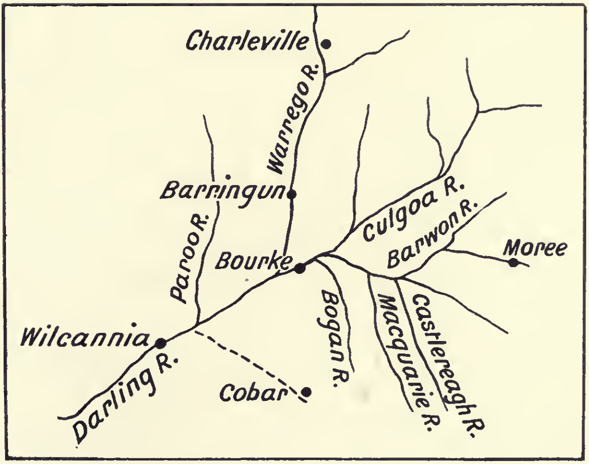

Fig. 26. Upper Darling—a normally branched stream—(after Taylor).

Another feature of low grade streams is their tendency to form extensive twists and "wriggles" called **meanders**. (Fig. 27). In mature streams the river distance between two points is frequently many times the distance as the crow flies. When two points in a meander approach one another the narrow neck between is frequently cut during flood time (as happened on the Hunter River at West Maitland), and the course of the river is thereby straightened. The discarded channel becomes silted at both ends forming what is known in this country as a **billabong**. The same structure is called by the American writers an "**ox-bow**" **lake**, and this term has become settled in physiographic terminology. By degrees such a billabong passes through the stages of a lagoon, and a swamp, and finally becomes an alluvial flat.

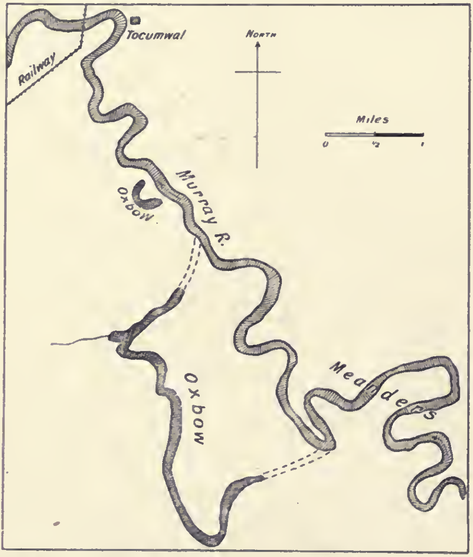

Fig. 27. The Murray at Tocumwal (after Taylor).

The lower course of the Murray lies between considerable cliffs composed of (geologically) very recent rock; in fact, the limestones formed in the Tertiary sea. This cliff structure, expressing juvenility of stream development, is due to uplift. In this statement lies a principle of wide reaching application. **Uplift and youthfulness of stream development constantly accompany one another.** Uplift amounting to thousands of feet has been general throughout Australia since the time when the sea occupied the area now drained by the Lower Murray. This uplift did not occur as a single great "jump" but was consummated by a series of slow vertical movements, sometimes upward, sometimes downward, with more or less prolonged intervening periods of rest during which the streams progressed towards maturity of development. Nor were the earth movements of equal intensity everywhere; some parts were uplifted to upwards of 7,000 feet, others participated less in the upward movement. The result has been extensive warping, fracturing and tilting of great blocks of the land surface, and these differential movements have been responsible for the diversity of scenery and particularly for the vagaries of the rivers in eastern New South Wales.

Let us now follow in some detail the effects of this unrest upon a few streams which must serve as examples for the rest.

Before the uplift asserted itself the land surface was worn down to the condition of a "peneplain," and the rivers had adjusted themselves almost completely to the irregularities of rock structure. In this way there arose numerous north and south valleys, all with the imprint of age upon them. Such an adjustment of streams to rock structure is very perfectly developed on the northern side of the Lower Hunter Valley. (Fig.

28). Streams owing their position to such a gradual process of adjustment are called subsequent streams. The uplift began, and a short steep slope to the eastern seaboard was produced. Down this slope rapid streams found their way, and in consequence of their great erosive power they quickly gnawed their way inland and lengthened their courses in that direction. It was not long before they found their way into the valleys of the placid streams flowing north and south on the plateau surface. The older streams were **beheaded** and their head waters diverted into the younger east and west rivers, which, increased in volume, by the waters they had captured carried on their work of erosion with renewed activity. Such a process as this is called **river piracy,** and has been active throughout the whole of the New South Wales coast and highlands.

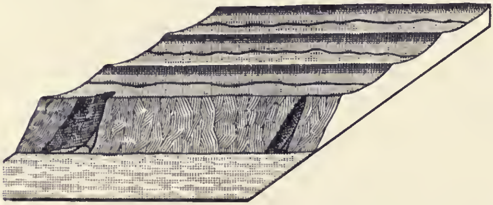

Fig. 28a. Mature longitudinal valleys on an uplifted peneplain; with the beginnings of two steep consequent streams cutting into the steep coastal scarp.

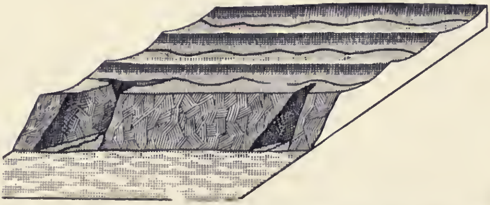

Fig. 28b. The southern consequent stream has cut back and "captured" a longitudinal stream, and reversed the direction of flow of part of it.

A very striking example of it is afforded by the Shoalhaven River. Near Marulan (116 miles from Sydney on the Southern Railway), this river makes a most extraordinary right angled bend. The general surface of the country is an almost level plateau about 2,000 feet above sea-level. A little to the west the Wollondilly flows northwards in a typically mature valley; but the Shoalhaven rushes along in a narrow V-shaped gorge 1,600 feet in depth. The Upper Shoalhaven flows to the north parallel with the Wollondilly. The explanation is not far to seek. Standing on an eminence, one can trace the course of a typical mature valley, which is the continuation northwards of the line of the Upper Shoalhaven, and which leads into the watershed of the Wollondilly. But this valley is dry, and carries no stream. In it, and right to the brink of the stupendous chasm of the present river, occur very coarse gravels with a little gold, exactly similar to the gravels of the stream below. They could not have been formed under existing conditions of topography and the conviction is forced upon us that this dry valley and its gravels were the work of the old Shoalhaven at a time when, flowing on the plateau surface, it was part of the Wollondilly system. (Fig. 29).

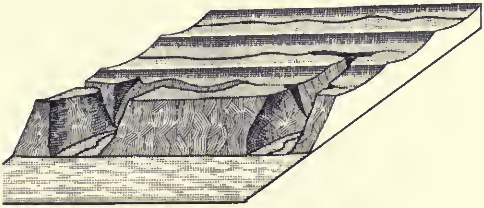

Fig. 28c. A still more advanced stage of river piracy, both consequent streams have captured longitudinal valleys.

It is certain that this capture took place a very long time ago in terms of years, and perhaps fairly early in the period of uplift. Succeeding upward movements have increased from time to time the velocity of the stream, or **rejuvenated** it, so that the appearances of youth have been retained. The river has still nearly 400 feet of vertical cutting to do before it reaches base level and begins to widen its valley appreciably; its down cutting is so rapid in consequence of its steep grade and large volume that its tributaries have not been able to keep pace with it and tumble from the plateau level in waterfalls like those of Barber's Creek, Bundanoon, and the Fitzroy Falls.

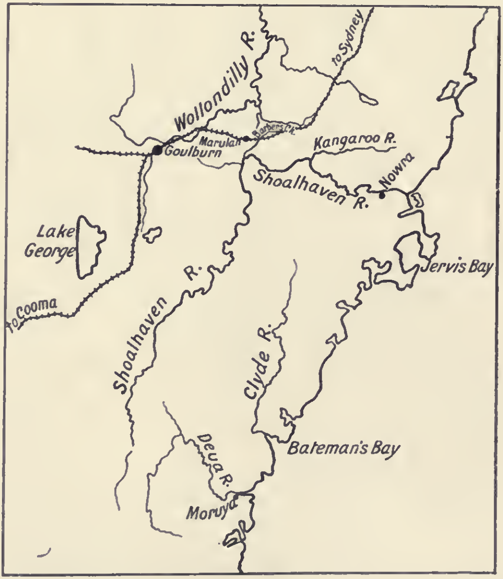

Fig. 29. The relationship between the Shoalhaven and Wollondilly Valleys.

It is worthy of note that the uplifts which have rejuvenated the short, swift Shoalhaven have performed the same office for the Wollondilly; but the latter stream has a much longer journey to the sea than the former, and also has the disadvantage of much harder rock materials to cut through, hence it has been unable to deepen its valley sufficiently for its own protection. The tributaries of the Shoalhaven are threatening the Wollondilly in several places and further "piracy" is imminent, (geologically speaking).

This example has been dealt with at some length because of its comparative simplicity, and because the same principles apply all along the coast. Probably most of the L and T shaped streams have had a similar history. The Moruya, Clyde, George's River, Hawkesbury, Hunter and Clarence all fall into this category. In the case of George's River faulting near Bankstown has assisted very materially in the process of diversion of the original north flowing streams which entered Parramatta River near Granville.

In the case of the Hunter System this piracy has taken place to a remarkable extent. The "structural" river and the "geographical river" are not the same: the Upper Hunter is the latter but undoubtedly the Goulburn and Lower Hunter (below Denman) form the structural stream of the region. The map (see frontispiece) indicates that the Main Divide is practically linear from near the Victorian Border to Queensland, with the important exception of that part drained by the Hunter. Here the Divide sweeps westward in a great loop, which is the work of the Hunter. All the steep east flowing streams brought into existence by the general uplift of the land "started from scratch," that is from the coast line, but with many unequal handicaps. The Hunter had to work on the relatively soft rocks of the Great Coal Basin and, hence, carved out its valley much more rapidly than its neighbours, the Manning on the north and the Hawkesbury on the south. (Fig. 30). The former had to contend with hard older rocks whose grain was in parts athwart its course; the latter with solid freestone a thousand feet thick which presented few vulnerable points of attack. Straight backwards did the Hunter-Goulburn gnaw its valley capturing and diverting, and even reversing, the older north and south streams of the western system piecemeal. The Williams, Paterson, Wallis Creek, Wollombi Brook, Falbrook, Upper Hunter, Isis, and so on, are its trophies. The head waters of the Macquarie and Namoi have been the chief

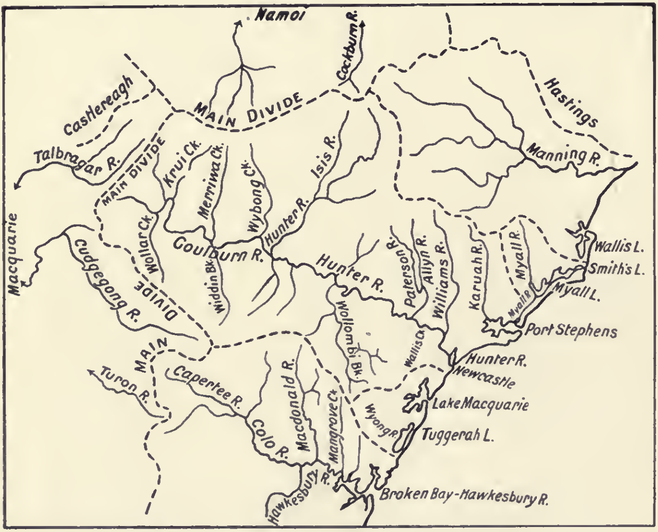

Fig 30. The Hunter River and its neighbours.

losers in this unequal struggle and are not even yet safe from its depredations. The Goulburn has worked back quite into the western slope of the tilted plateau so that the Divide at its head, near Cassilis, is much lower than it is anywhere else in Eastern Australia. This saddle or "col" has been termed a "geocol" on account of its great physiographic importance. It has a preponderating effect upon the weather conditions of the Hunter Valley and upon its vegetation also.

On account of the softness of the rocks with which it has had to deal the Hunter has attained a maturity of development much more complete than that of any other coastal stream.

The encroachment of a coastal stream upon the western watershed is shown admirably by the Upper Macleay. Its head-water streams flow as mature streams, the remnants of a former generation, on the surface of a plateau from 3,000 to 4,000 feet above sea-level, **while the country between them and the coast rises to heights of upwards of 5,000 feet.** The general slope of the land is towards the west, but the vigorous eastern stream has cut through the old divide and into the lower country beyond it. On their way to the sea the present rivers flow more or less inland at first, but turn suddenly eastward and drop over magnificent falls like those of the Tia, Apsley, Wollomombi, and others, whence they romp through profound cañons guarded by inaccessible cliffs, until, becoming more sedate owing to increasing maturity, they emerge in the opening valleys of the lowland, whence they proceed more soberly to the sea. It is the rejuvenescence due to uplift which has caused the mature streams of the upland to exchange their open valleys for the waterfalls and cañons of their middle courses. (Fig. 31).

In the extreme north-east of New South Wales there is ample evidence of the importance of river piracy as an agent in the production of present-day topography. The great barrier of the Macpherson Range is breached by a remarkable "air gap"* between the peaks known as Tenduragan and Wagawn. Its floor lies some 800 or 900 feet above sea-level. A

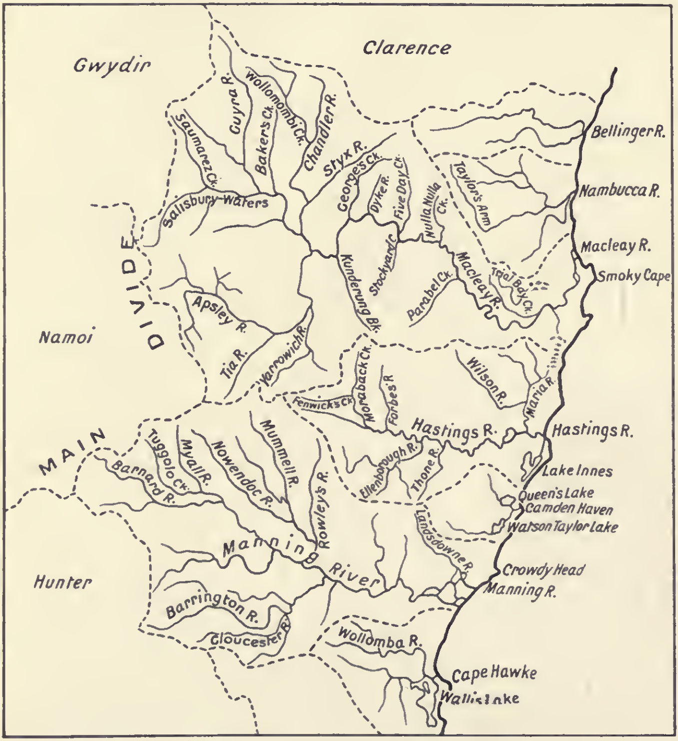

Fig. 31. The Manning, Hastings, and Macleay Rivers

similar air gap through the divide between the Tweed and Richmond leads us into the latter watershed; and it is extremely probable that a similar depression occurs near Mount Belmore, leading into the Clarence Basin.

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*An air gap is a depression in a divide, produced by stream action, but no longer occupied by a stream of importance because of modifications of the old drainage systems.

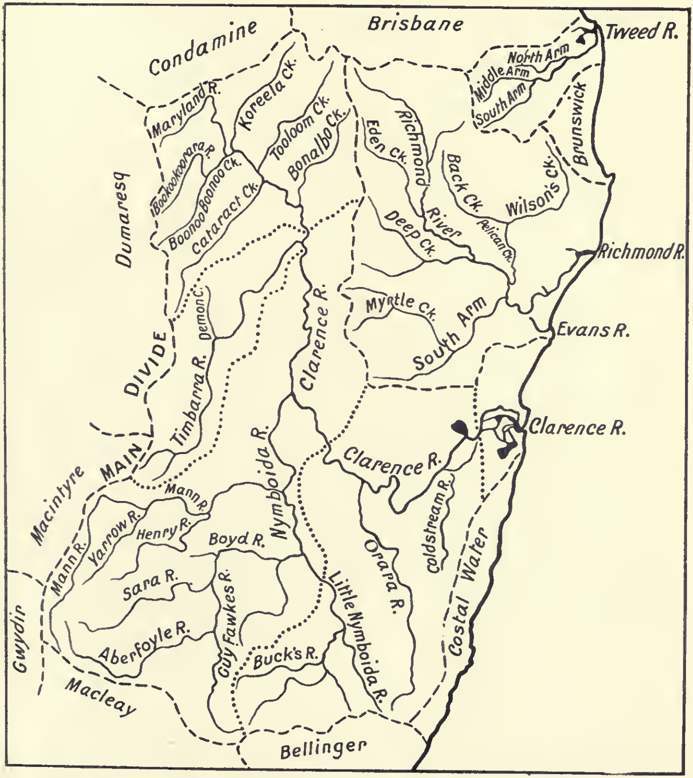


Fig. 32. The Clarence River and its neighbours. The broken lines indicate divides between independent river systems, the dotted lines minor divides within the Clarence watershed.

These air gaps are the sole remnants of a once continuous mature stream, flowing almost meridionally, which has been dismembered and almost obliterated by the piratical Tweed and Richmond. (Fig. 32).

The cases of river piracy considered above have been, almost entirely, the work of the rivers themselves. Certainly uplift and tilt of the land surface were the ultimate causes, but, beyond this, earth movement has not been a very noteworthy feature.

Let us now turn to a different class of phenomena in which the dominant factor is folding or faulting of the earth's crust.

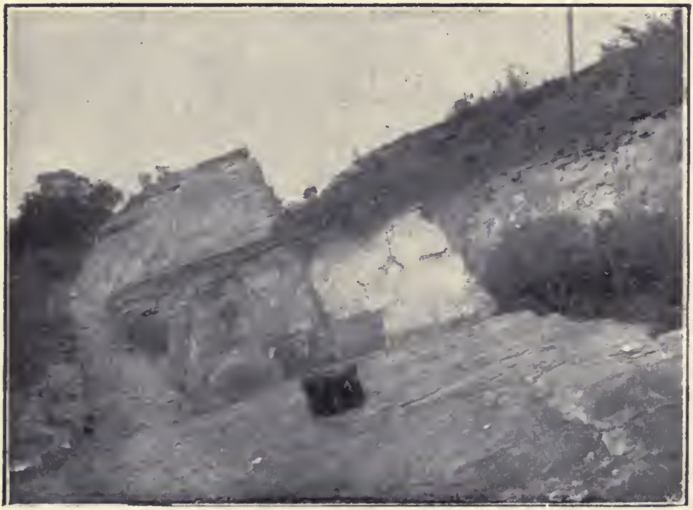


Fig. 33. The actual fold slope of the Sandstones on Lapstone Hill.

Following the Nepean from Camden to Penrith we have a very remarkable example of the effects of an earth fold on river development. (Fig. 34.) Above Mulgoa the valley is broad and mature, and from Mulgoa to Penrith the same gently undulating country continues, limited on the west by the steep escarpment forming the eastern face of the Blue Mountains. But this easy track is not the one followed by the river; it deliber-

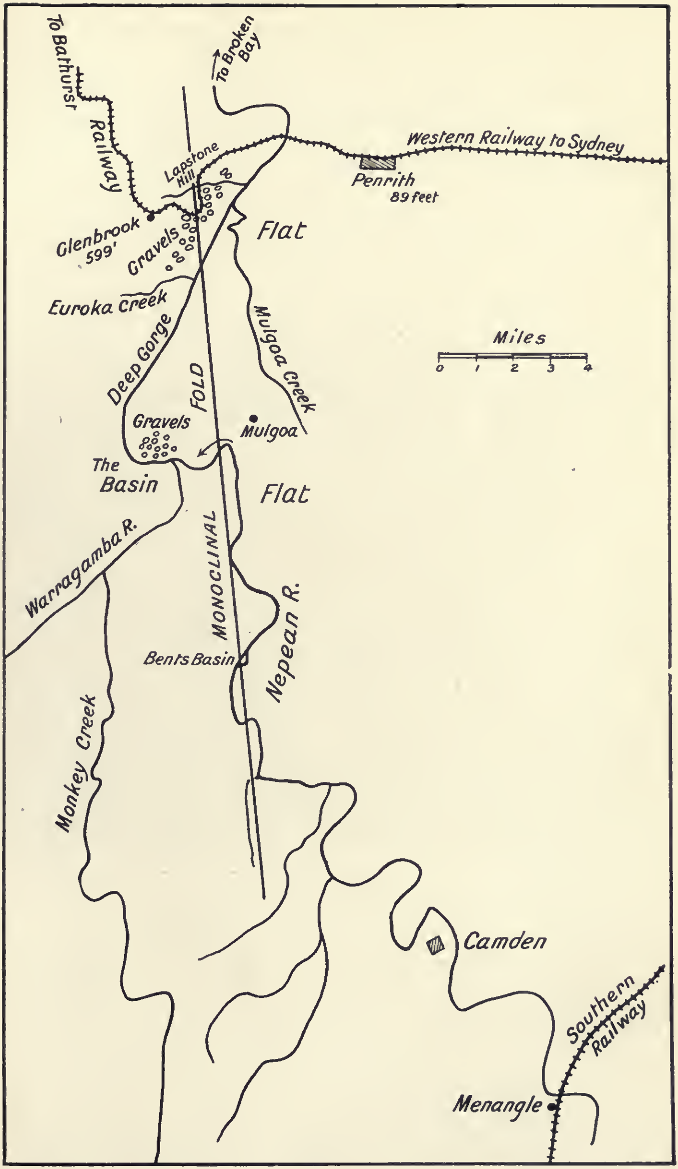
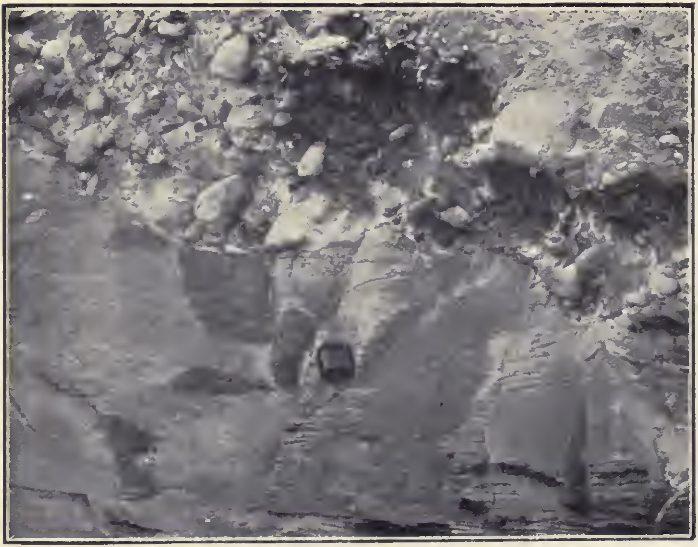


Fig. 34. Monoclinal fold, and Nepean Fold-scarp Valleys (after Taylor).

ately forsakes the plains and dives into a rocky gorge about 600 feet in depth. This it follows for miles until it again, apparently without rhyme or reason, emerges into the plains near Penrith. (Fig. 34.) An examination of the rocks of the escarpment shows that they form part of an extensive earth fold lying about north and south. Further, upon the top and sides of the escarpment there exist extensive patches of river gravel in all respects similar to that formed by the river of to-day. (Fig. 35.) The railway tunnel near Glenbrook passed through the bottom of such an old river channel.* North of the gorge the old gravels drop to the level of the plain.



Prof. David.

Fig. 35. High level river gravels of the old Nepean Channel.

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*David, T. W. E. D., Proc. Roy. Soc. N.S. Wales, xxx., 1896, pp. 32-70.

These facts show that **the Nepean antedated the escarpment.** It followed the course now indicated by the old gravels and was probably a moderately mature stream. Then the "bulge" in the earth's crust began

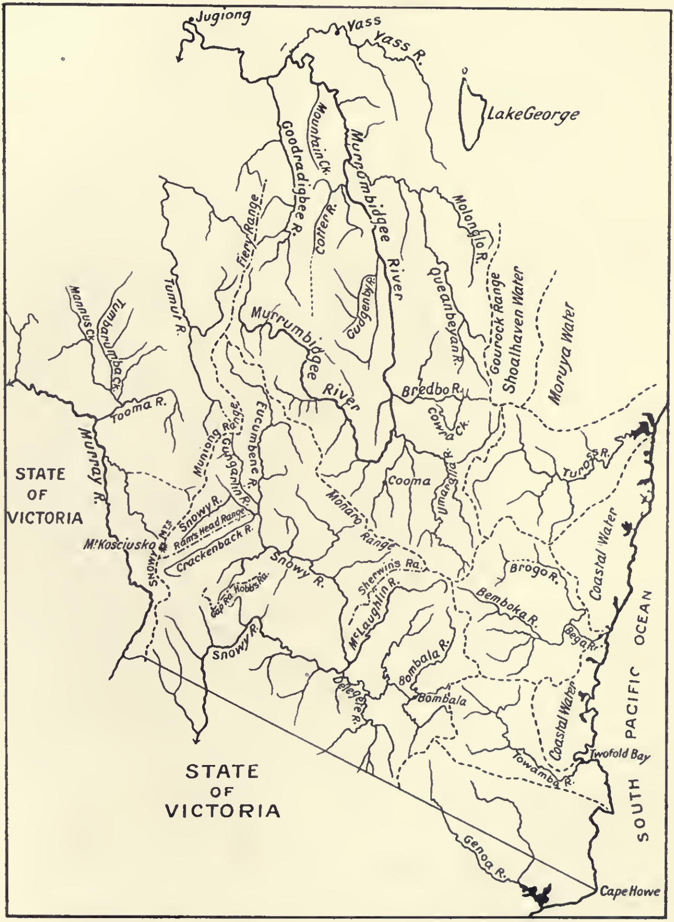

Fig. 36. The Snowy and Murrumbidgee River systems.

to make itself felt and the stream set to work to saw down the rising obstacle in its bed. Had the rise of the bulge been rapid the stream would have been diverted and would have flowed along the foot of the slope from Mulgoa to Penrith. As it was the movement was very slow and the river kept its position approximately, and was just able, by downward cutting, to maintain its channel against the force of uplift. It has had no energy to spare to widen out the valley, hence the remarkable "saw-cut" gorge. It is quite possible that the uplift is still going on slowly.

The tributaries of the Nepean in this part of its course, Glenbrook and Euroka Creeks, show similar youthful features, the valleys widen out only at places, where, as at "The Basin" and Euroka Farm, more easily eroded rocks occur filling the pipes of old volcanoes.

A river which maintains its course in spite of opposing earth movements is called an **antecedent** stream.

Earth movements have had a preponderating effect in the south-eastern corner of New South Wales. Here we have the highest mountains in the Continent and the rivers which radiate from this "mountain knot" afford very striking examples of the extraordinary effect of earth fracture and tilt upon a well adjusted stream system.

A general glance at the map (Fig. 36) at once suggests some very close relationship between the Snowy and the upper Murrumbidgee, and recalls the condition of affairs at the head of the Hunter. The resemblance is strengthened by the occurrence of an enormous loop in the Main

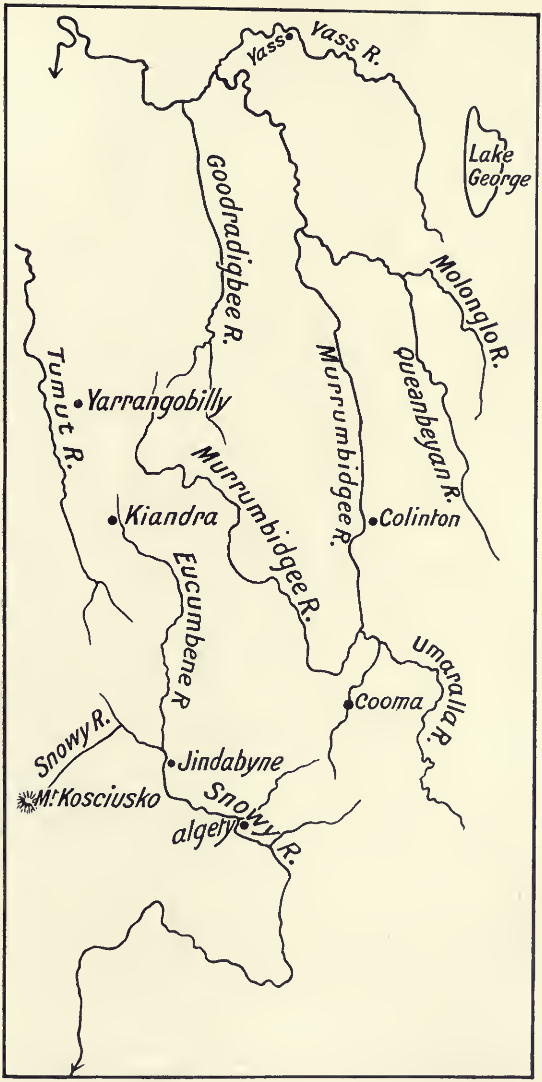

Fig 37. Map of part of Murrumbidgee and Snowy River systems (Eucumbene River).

Divide. When, however, we come to study the facts a little more closely we find the similarity is only superficial; in the case of the Hunter it is the eastern stream which has captured the western one, while in the south it is the Snowy which has lost its territory to the Murrumbidgee. This case of piracy is due not to stream action pure and simple, but to the fracturing of great blocks of the crust and differential movements between them. One block has been thrust upwards to over 7,000 feet in height and forms the Kosciusko mass. Others at lower altitudes have been tilted so as to possess one long gentle slope and one short steep one, and these changes of level are faithfully mirrored by the phenomena of river development.

The Murrumbidgee rises near Yarrangobilly and sets out in a south-easterly direction with the obvious intention of reaching the Pacific, but, just short of Cooma swings right round and heads northwards. A glance at the map (Fig. 37) will show that the Eucumbene, structurally the main stream of the Snowy River, is collinear with the Upper Murrumbidgee, and is separated from it by a short distance only. This strongly suggests that capture of the Upper Snowy by the Murrumbidgee has occurred. This capture of a coastal stream by one of the Western system is the converse of what has happened at the head of the Hunter Valley, and has been brought about by the earth fracturing and tilting above described.

Süssmilch* describes graphically the structure of this part of the valley. The Main Divide, south of Cooma, is an almost level plain. "Standing on Bunyan Hill

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*Süssmilch, C. A, Physiography of the Southern Tableland of N.S. Wales, Jour. and Proc. Roy. Soc. N.S. Wales, Vol. xliii., 1909, p. 351.

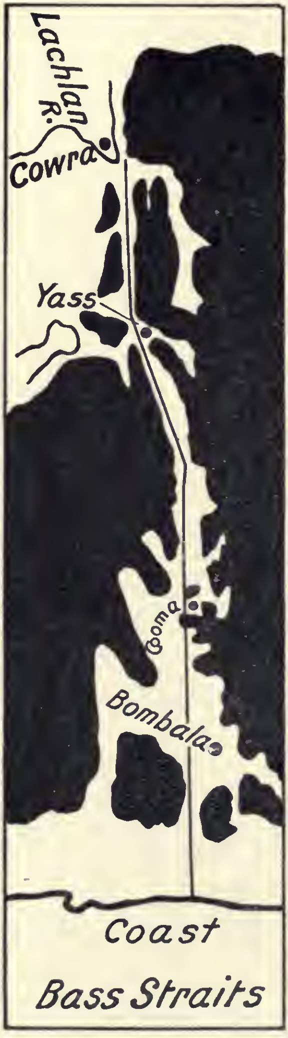

Fig. 38. Rift Valley of Snowy-Murrumbidgee systems (Taylor).

near Cooma and looking north along the valley of the Murrumbidgee in the direction of its present flow, one sees what appears to be a continuous chain of hills standing athwart its course and apparently blocking any possible drainage in that direction. Looking south on the other hand, one sees the Monaro plains stretching west and south, and bounded in the far distance by a low range of hills—the Main Divide. In this range and due south from the observer, there is a gap many miles in width. No stream flows through this gap—it is a "wind gap." Anyone unfamiliar with the direction of the flow of the streams, would from this point of observation, certainly come to the conclusion that all the drainage was flowing to the south and through the above-mentioned wind gap. Yet this same gap forms part of the existing divide and through it extends a great plain. (Fig. 38.) The ridge seen to the north originally formed the divide between the Snowy and Murrumbidgee systems. Through warping and uplift of the plateau surface the drainage has been disturbed and brought into its present condition. Through the ridge (near Colinton) the Murrumbidgee exhibits quite youthful features, while, both up-stream and down-stream, a much higher degree of maturity has been attained.

The Snowy River itself also shows signs of modification through the action of "faulting." At the head of the Eucumbene the stream flows in a gorge cut through one of the faulted blocks.* Past Kosciusko it flows in a flat-floored valley. "Rising ground appears to block the river below Jindabyne but in reality the stream pierces the obstacle by means of a gorge. Alluvial terraces in the broad valley floor indicate a tiny lake only just drained by the deep gorge which has almost reached Jindabyne." Down stream the gorge becomes deeper and pierces a fault block which forms

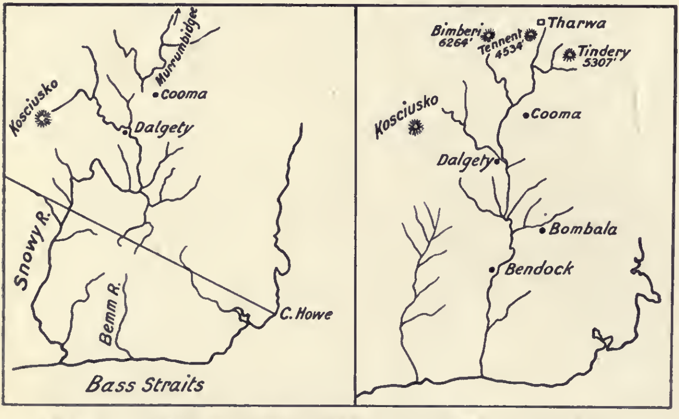

Fig. 39. Present and past courses of the Snowy River (Taylor).

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*Andrews, E. C. Geographical Unity of Eastern Australia. Journ. and Proc. Roy. Soc. N.S. Wales, Vol. xliv., 1910, p. 445.

one wall of a sunken area now drained by the Mowamba. From the lip of the ravine by which the stream traverses this range, the country may be seen to fall away steeply to a low-lying plateau surface at Dalgety. Thence the Snowy may be seen approaching a great mountain pile (fault block) to the south, which it penetrates in turn in profound ravines. Taylor is of opinion that the country about Cooma and Bombala was drained originally by a stream running

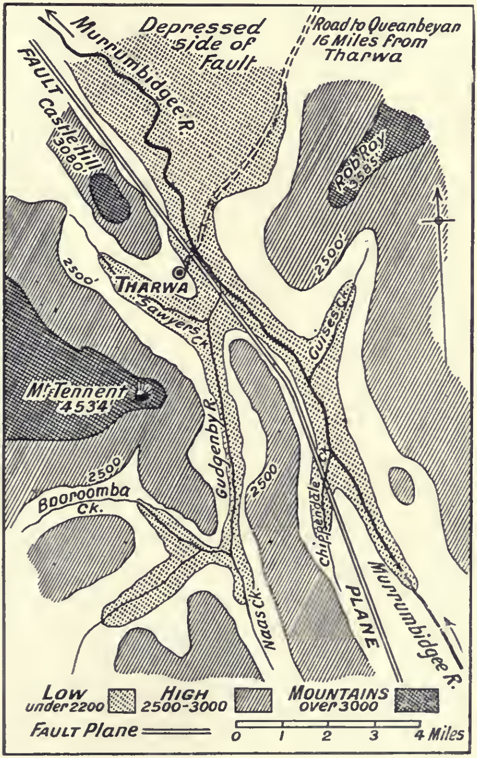


Fig. 40. Old Divide of Snowy-Murrumbidgee near Tharwa (Taylor).

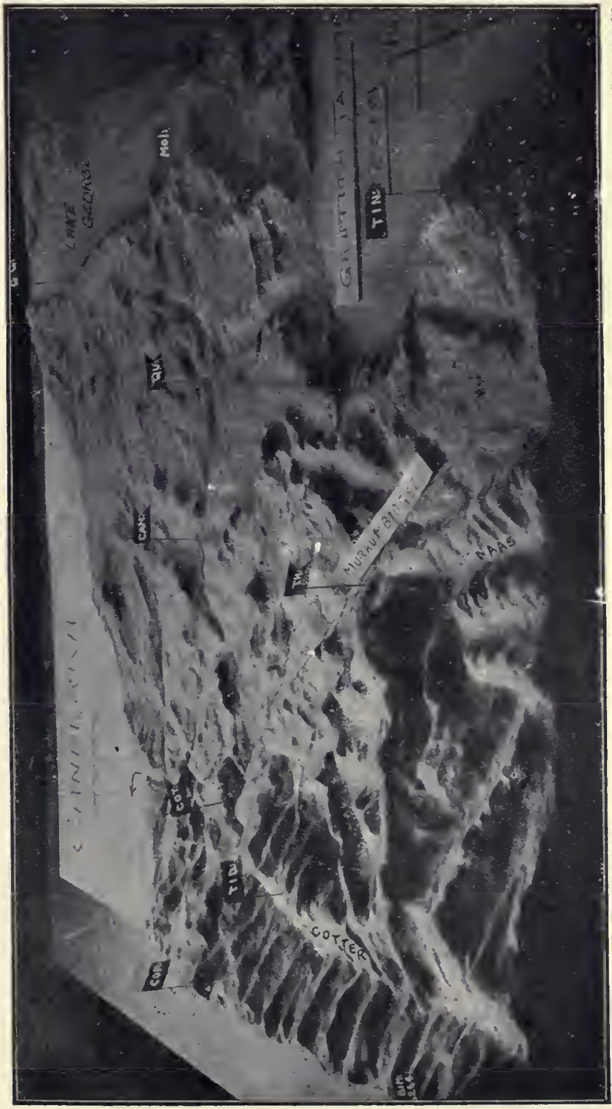
into the Bemm and not into the Snowy, as indicated in Fig. 39.

He also shows the probable old line of water parting between the Snowy and Murrumbidgee Rivers marked now by the high "residuals" of Mount Tennent and Rob Roy, near Tharwa, as shown in Fig. 40.

Another very striking example of the effect of earth movement in river development is afforded by the Murrumbidgee and its tributaries in the neighbourhood of the Federal Territory. (See Fig. 41). Taylor states:—

"The Molonglo rises in the Gourock Ranges (to the right of the model) at an elevation of about 4000 feet. It flows north-west for twenty miles through undulating country, and then reaches the flat expanse of the Molonglo Plains. This area looks as flat as a billiard table (see photo.) for five miles, and is obviously composed of silts. How is it that the river so soon exhibits features of senility, and how is the still more extraordinary fact to be explained that on the far side of this plain it cuts abruptly across the Cullarin Ranges in a defile 150 feet deep (*Mol*: in photograph); from which it emerges ten miles lower down at Queanbeyan. Here we have youth and old age cheek by jowl. Then it flows westward through flat plains with occasional monadnocks (around Canberra rising to a further height of 800 feet) until it approaches the Murrumbidgee, when it renews its youth once more, and passes to join the big river down a narrow valley excavated to a depth of several hundred feet below the level of Canberra Plains.

"These phenomena form a beautiful example of the effect of local uplift. The river Molonglo once flowed normally over a surface which had for the most part reached late maturity. There were only residuals of



By permission of the Department of Home Affairs N.S.W.

Fig. 41. Model of Federal Capital Site at Yass-Canberra.

the old land surface (monadnocks) remaining above the river level. Then two faults broke the crust into a block about twenty miles wide. The tilt-block gradually lifted on the east and sank on the west. This happened so slowly that the Molonglo could cut a notch (the Defile) in the Cullarin scarp to a certain depth, but apparently not completely, for the river has deposited a great depth of silt in the plains and escapes at 2400 feet above sea level over a hard rock sill. The big river Murrumbidgee cut down more quickly along the western fault, and the Molonglo notched the old plain to get down to the level of the main stream. (Fig. 42.)

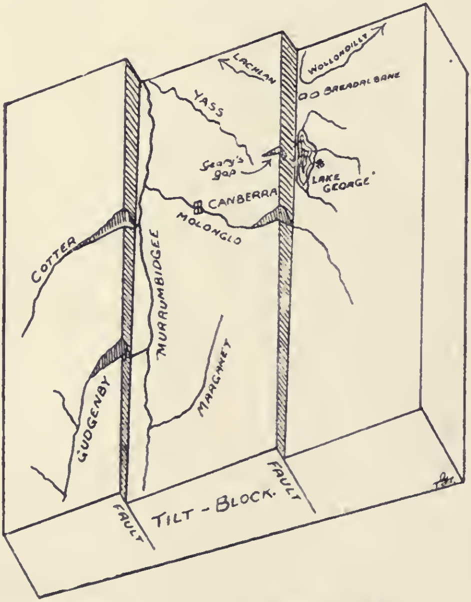
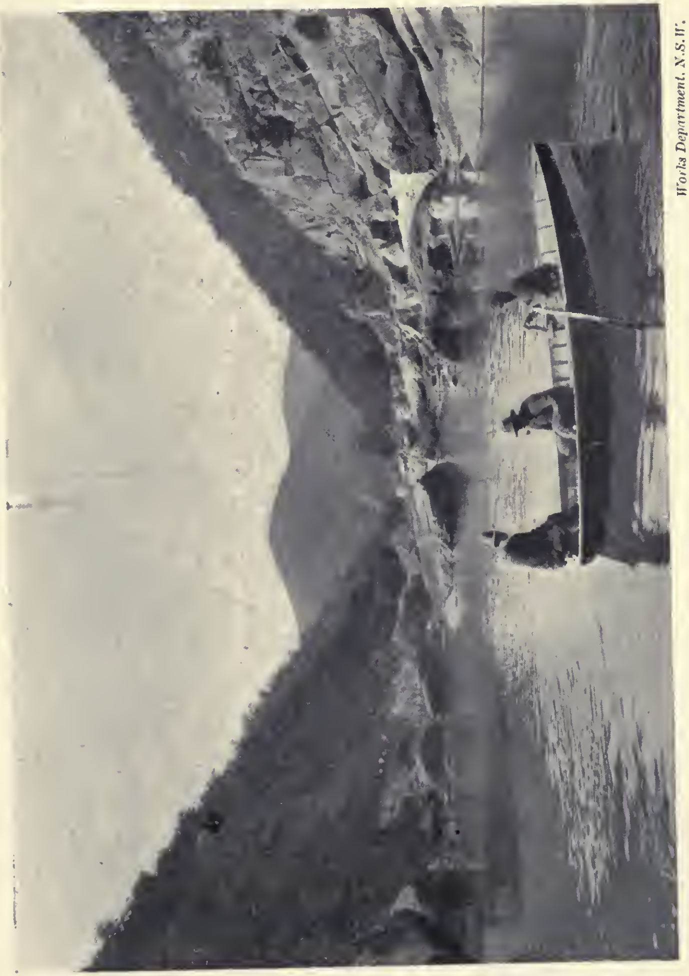


Fig. 42. The Canberra tilt block (Taylor).

"Here the statement that youth implies uplift is abundantly proved. The defile just to the west of



Works Department, N.S.W.

Fig. 43. Rocky Gorge of Murrumbidgee River near Burrinjuck.

the Molonglo Plains is the uplifted edge of the block. The narrow valley at the junction is due to the more rapid erosion by the main (Murrumbidgee) river, which has left the tributary Molonglo **at a higher level**, and so practically affected the latter, as would an uplift. The silt of Molonglo Plain is a region at base level—so far as the headwaters are concerned—and so has all the features of senility. The undulating broad valley of Canberra shows the normal **mature** topography before the period of unrest, earthquake, and faulting resulting in the tilting of the Canberra block.''

The youthful character of the Murrumbidgee Valley at Burrinjuck below Yass is shown in Fig. 43.

Still another class of stream accidents has to be considered, namely, those caused by the accumulation of an obstacle in the course of a stream.

A landslip on a large scale may temporarily dam a river and cause the formation of a lake, or may even cause the stream to break over some low point in its valley walls. Usually, however, landslips are on far too insignificant a scale to produce any permanent effect.

It is quite otherwise with volcanic eruptions where vast masses of lava and ash accumulate in incredibly short spaces of time. Such accumulations produce the most far-reaching aberrations in river courses. A river whose trend is determined by such a geological accident is often referred to as an **insequent** stream.

A splendid example of such a stream is afforded by the Castlereagh River. As above described most of the southern tributaries of the Darling run in a north-westerly direction. The Castlereagh, however, runs south-easterly then swings round a half circle and finally enters the main stream in the same general direction as its neighbours. In the bend lies the great volcanic mass of the Warrumbungle Mountains. As explained in Chapter V, these mountains form part of a great series of volcanic rocks whose general trend is south-west and north-east. This mass rose athwart one of the normal rivers of the Darling system, and diverted it in the way described.

Another example is afforded by the Manilla River which, formerly flowing towards Bingara, has been diverted by the volcanic range of the Nandewar Mountains.

By the eruptions which produced the great floods of basaltic lavas covering vast areas of the New England Plateau and other parts of the State, pre-existing topography was almost completely obliterated. Following the laws of hydrostatics the liquid lava poured down the old stream channels and congealed there. Flow after flow occurred and even considerable eminences became submerged under great even stretches of lava. The general slope of this lava plain being fairly uniform the drainage developed on its surface followed its inclination. Pre-lava streams had adjusted themselves completely to geological structure, hence the directions of the older and newer streams are quite discordant in many instances. The gravels of the older streams, many of them auriferous, stanniferous or gem-bearing, are preserved as "deep-leads" under the covering of basalt.

The case of Vegetable Creek* is interesting. The grade of the deep lead is much more gentle than that of the present day stream. Both trend in approximately the same direction but in a distance of 12 miles the "deep lead" passes from 30 feet below the present creek level to 220 feet above it, an effect due to the uplift of the plateau since the time when the older stream was flowing.

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*David, T. W. E.

The fate of the lower portions of the streams deserves some consideration. The production of a broad valley to a great extent filled with river-borne sediment has been described above as the normal condition of maturity. If the stream debouches into a sea devoid of currents the detrital material is pushed forward and extensive reclamation takes place. This is the case with the Mississippi, Ganges and many other of the world's great rivers. Our coastal rivers have to contend with a strong shore-current which sweeps the detritus along the coast and spreads it over the continental shelf. Only where a river enters a bight, as does the Hunter, is there any very extensive development of delta formation. On a smaller scale similar delta formation is observed at the mouths of all the

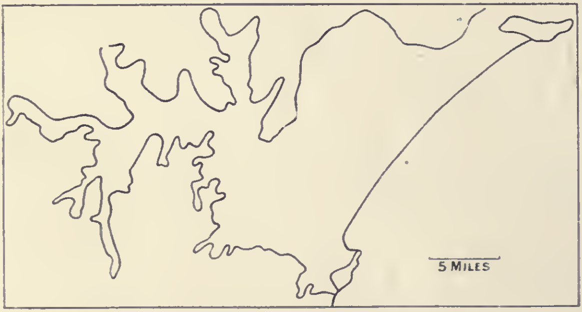


Fig. 44. Filled up Estuary of the Hunter River.

rivers north of the Hunter, but in every instance the reclamation is limited by a curved line joining the projecting headlands north and south of the rivers' mouths (see Chapter X.).

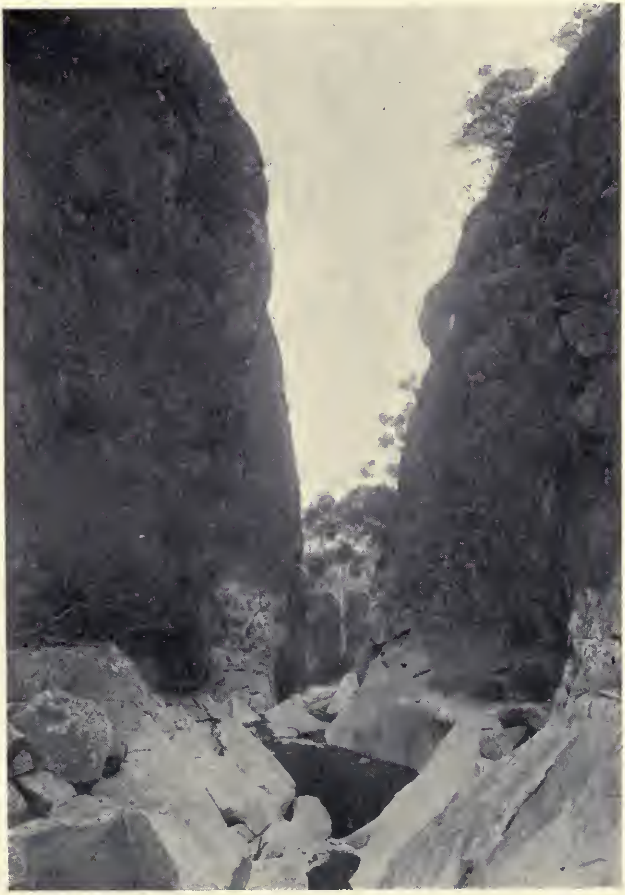


Fig. 45. Canon at Tallong in the Shoalhaven Valley showing youthful topography the result of recent uplift.

For delta formation to proceed without interruption stability of the land surface is essential. As we have seen however the land has been undergoing uplift and depression intermittently. Uplift causes rejuvenescence of the streams (Fig. 45) while depression causes the sea to rush in and drown out the lower valleys of the streams. The effect of this drowning has been to make a series of magnificent inlets along the coast line, of which Broken Bay and Port Jackson are typical examples (Chapter X.).

CHAPTER IX.—THE LAKES OF NEW SOUTH WALES.

(T. G. TAYLOR, B.A., B.E., B.Sc.)

A lake is a somewhat abnormal physiographical feature, as a few moments' consideration will show. The drainage of a country has normally **one fairly continuous slope** along the bed of creek or river, from origin to mouth; whereas a lake implies a barrier of some form which has dammed the water and constituted a local deepening, or even a total cessation, of the stream or river.

It will be seen that the investigation of the origin of a lake often consists very largely in a determination of the conditions obtaining at its outlet. Thus the Kosciusko lakes are confined by huge mounds of granite boulders, which are almost certainly relics of ancient glaciers. The coastal lagoons are bounded by sand dunes, due to wind and tide. Lake Bathurst has its outlet blocked by extensive gravel deposits, while Lake George has no outlet of any description, pointing to large changes in the surface features of its basin within fairly recent date.

The low average rainfall of the State, coupled with the somewhat short and rapid courses of the rivers of the littoral, where the rainfall is heavier, has resulted in lakes being conspicuous by their scarcity. However, there are represented in New South Wales five or six groups, of the following types:—

A. **Mountain lakes**, such as Hedley-Tarn and the Blue Lake.

B. **Isolated lake basins**, of which Lake George is a striking example.

C. Lakes, such as Lake Bathurst, occupying **lateral valleys**, which have been blocked by the silt, etc., of the main river.

D. **Lakes of the Interior** flooded by rivers in wet seasons, such as Lake Cowal, and, probably, Lakes Victoria and Menindie.

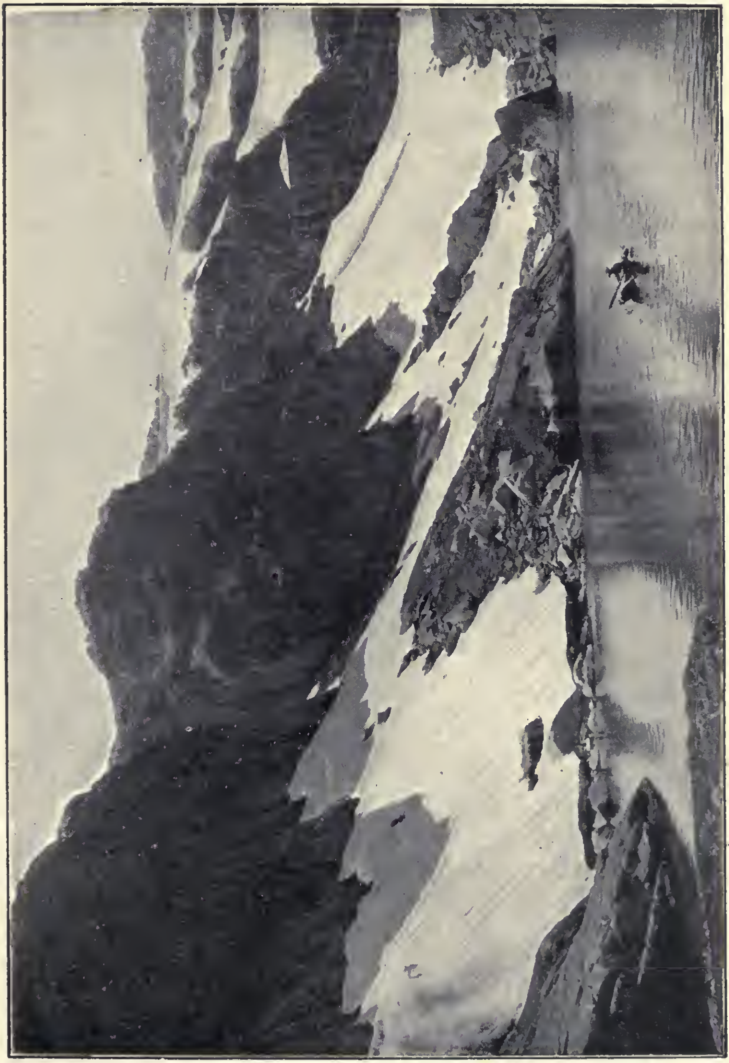
E. and F. These comprise **coastal lagoons**, more fully described under the section on shore-lines, and **ox-bows.** The latter merely representing river deviations, have no permanent form, and are better included in the description of rivers.

A. **Mountain Lakes.**—In the south-eastern portion of the State known as the **Monaro,** the country has a special character of its own, both as regards relief and climate. South of the basin of the Murrumbidgee lies the area of uplands in which rise not only this river, but also the Murray and the Snowy. The Great Divide broadens into a huge rugged moorland of some 5000 feet elevation, covered with heath and stunted gums. Above this rise the ridges constituting Kosciusko, the Bogongs, etc., which indeed are approached so gradually that they project only about 1500 feet above the surrounding level. However, the absolute altitude is sufficient to ensure the presence of extensive areas of snow throughout the summer, at an elevation of 6000 feet, and these feed the numerous bogs, creeks, and rivers which characterise the Monaro country.

Even in the Koseiusko district the lakes are small, though the average rainfall is about 55 inches. The Blue Lake is only about one-third of a mile in diameter, while Lakes Albina, May, Hedley, and Club are very much smaller. (See Fig. 46).

On 10th February, 1907, the eastern flank of the ridge between Kosciusko and the Blue Lake was covered with a chain of miniature snow-fields, some twenty-five in number; with an average length of 200 yards, 20 yards across and five feet thick. This chain constituted the permanent summer supply for the various lakes and rivers. But it is a mistake to suppose that a plentiful supply of water is the main essential for a lake. If such were the case we should not find the lakes at the head of the streams, but lower down where the drainage had accumulated. All the lakes around Kosciusko are within a mile of the ridge, which leads us to suppose that the **altitude** is in some way a factor in the problem.

The lakes occupy the upper portion of rather narrow valleys, and in all cases the lower barrier consists of a huge irregular mound of granite blocks, nine or ten feet in diameter in many cases. One such typical barrier below Hedley Tarn was twenty-five feet above the water-level, about 200 yards wide, and 600 yards long. The only agent capable of transporting such large blocks is **Ice**. The former extent of the Ice-sheet, or Glacier, leading to the formation of these barriers,



Prof. David.

Fig. 46 The Blue Lake, Kosciusko, lying in rock basin excavated by former glacier.

known as **Moraines**, has been investigated by Professor David and other geologists.* They consider that the glacier extended from Mount Twynam to Hedley Tarn, a distance of 1½ miles, and was at least 400 feet thick. We may, therefore, picture the flanks of Kosciusko as covered, about ten thousand years ago, with a perennial load of ice. On this glacier fell rock *débris*, torn down by avalanches, portions of which gradually descended from the upper surface through huge cracks in the ice, became fixed in the lower surface, and converted the whole into a gigantic "harrow." Hence arose the grooves which may be seen on the granite surfaces over which the glacier passed, many of which are several inches wide and over an inch in depth. The transported rocks were finally left in **curved ridges** at the lower end of the glacial sheet, and on the dwindling of the latter remained as barriers across the glacial valley, conveniently situated for lake formation.

The **Blue Lake** lies immediately at the foot of Mount Twynam, on the eastern flank of the range. The snow sheet persists on this side all the year round, in the form of a somewhat porous granular material, *névé*, rather than as ice or true snow. Here it is protected from the mid-day sun and from the prevailing westerly winds. The cliffs immediately around the lake are about 300 feet high, and have a slope of 1 in 1. The water from numerous small waterfalls rushes down into the lake, giving rise to small detrital "fans," where they deposit their burden in the lake waters. Here, wherever there is a little soil, blooms a characteristic flora of everlastings, daisies, ferns, etc. As the outlet is approached, the bare granite pavements are hidden by **moraine** material in the form of angular blocks of granite, which are themselves in many cases covered by a low spreading heath. This growth renders one's foothold treacherous in the extreme. Through a cleft in the moraine, about twelve feet wide at the water level, the stream rushes towards **Hedley Tarn** 500 yards to the south-east and 100 feet lower. There the waters spread out over a sedgy flat which is gradually filling Hedley Tarn. The moraine, or series of moraines, for it is 200 yards broad, constituting the south-west wall, has been breached at its western end, and from here the water flows over, under, or around the tumbled

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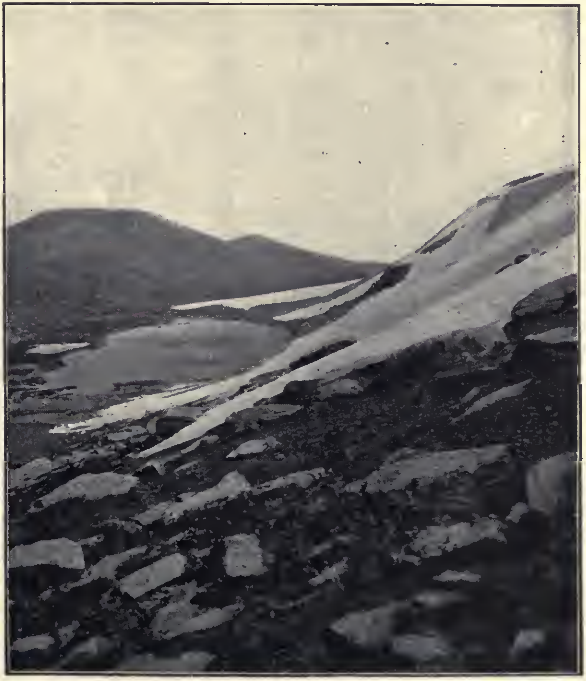
*See Proc. Lin. Soc. N.S.W., 1901. p. 5, David, Helms & Pittman.



Judge Docker.

Fig. 47. Lake Cootapatamba.

blocks of the moraine on its path to the Snowy River, six hundred feet below.

Lake May, at the foot of Kosciusko, and Lake Albina below Townsend, also owe their origin to the *débris* left on the retreat of small glaciers, and their physiography is essentially similar to that of the Blue Lake. (Fig. 47).

Granite Lakes.—Several small lakes occur on the granite areas of the Snowy Valley. Some are situated close to the Cooma-Jindabyne road, and bear euphonious aboriginal names, Coolamatong, Jillimatong, etc. They are usually more or less circular depressions in the granite less than half a mile in diameter with no very definite inlet or outlet. Several theories have been advanced to account for them. They have been doubtfully referred to glacial action, when the ice sheet reached far below its latest maximum. This is, however, highly improbable. Perhaps they are due to differential weathering of the granite surface. A local depression is first etched out by the action of drainage waters containing vegetable acids, etc., and the loosened material may be swept out by winds during periods of drought. Such an alternation would rapidly excavate fairly large hollows in a rock which in other parts of the world has been shown to readily lend itself to this method of erosion. On the other hand their presence on the low divide between the Snowy and Murrumbidgee suggests that they may be "loose ends" of the captured Snowy streams. This latter theory is supported by the fact that such lakes occur all along the Divide.

B. **Isolated Lake Basins.**—Lake George, commonly called the largest freshwater lake in New South Wales, is a striking example of this class. Let us glance at the land features which many thousands of years ago would have been observed in the triangle now defined by Collector, Tarago, and Bungendore. We must look

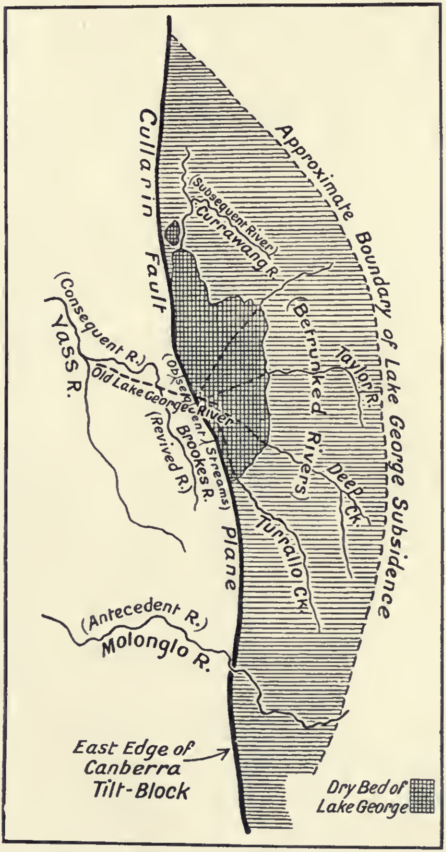


Fig. 48. Dry Bed of Lake George, showing former river system cut off by the Cullarin fault plane.

back to a time before the folding which gave us the east scarp of the Blue Mountains. Probably the Yass river then had a very important tributary flowing from the east somewhere in the position of Brooks Creek. This long dead river, which we may term "Lake George River," flowed across the modern site of Lake George and received Murray's Creek, Taylor's Creek, Deep Creek, and Turallo Creek, as indicated by the dotted lines in Fig. 48.

Currawang Creek probably flowed into the Wollondilly system, and has been diverted by the same agency which gave rise to Lake George, into the latter. The bed of Lake George **River** was, and is, occupied by huge boulders of quartz sometimes more than two feet in length, and by a layer of white clay below the former in which gold has collected. Later a series of earthquakes cracked the vertical layers of slate, which have a north and south direction, and the area roughly defined by the triangle before quoted, sank several hundred feet on the western side, the fall gradually decreasing to the east. The displacement was probably fairly rapid since the rivers, with the exception of the Molonglo River, could not keep pace with the movement. There results a long range of hills with a precipitous eastern face, bounding the west side of Lake George.* This range, the Cullarin Range, has an average level of abut 500 feet above the lake bed. It is, however, notched by a well-defined **gap** some 180 feet only above the bed, through which the old main southern road passed. This is known as Geary's Gap. The ancient Lake George River flowed out about 1½ miles south of this present lowest point, at an elevation of 250 feet above present lake level. This is proved by the presence of **high level river gravels**, which have been traced at intervals for nearly three miles. The old alluvial miners were keen enough to see that gold was probable in these gravels, though, as in the case of the Barber's Creek alluvial field (see p. 81), they had naturally enough no correct idea as to how river gravels came to be perched on the tops of high hills as in the present case. At Diamond Hill, between Brooks Creek and the Yass River, another deposit occurs exactly resembling that near Grove Creek. It is studded with mine shafts about 40 feet deep, sunk in 1860 during the Brooks Creek gold rush. Many years later a few diamonds were found in these alluvial gravels which have been made available for human industry by far distant physiographical changes. The lake was thus formed in the fault depression, and has possibly never had an outlet.

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*The Physiography and Origin of Lake George are fully discussed and illustrated in a paper by the writer. Read before the Linnean Soc. N.S.W. May, 1907.

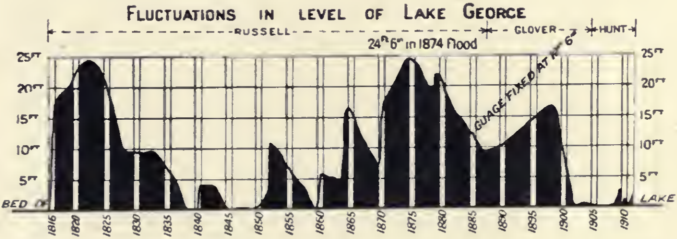

Fig. 49. Fluctuations in level of Lake George.

Australia is now experiencing a dry cycle, and as will be seen from the diagram showing the lake depths for nearly a century* (Fig. 49) the water has never risen within 100 feet of the amount necessary for it to overflow either at Geary's Gap, Collector, or into the Molonglo River to the south. These three are all possible outlets were the lake basin to fill up two hundred feet instead of the normal twenty.

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*For information on the Floods and contours of Lake George, the reader should consult the paper by H. C. Russell, Roy. Soc. New South Wales, 1886, from which the diagram above is copied.

In February, 1907, Lake George was practically dry. On the eastern side under Governor's Hill there was a pool about six inches deep and three miles long, fringing a central mudbank. Indeed, to the eye the lake bed looked like a perfectly flat paddock fifteen miles long and seven wide, though actual levelling shows a slight fall of a few feet in the mile towards the east. Grass grows outside a zone of mud surrounding the water, and this is leased to neighbouring stations for the pasturing of large flocks of sheep. A variety of saltbush has taken firm hold on the salty silt, and is readily eaten by the sheep. As water may be readily obtained at the foot of the steep gullies on the western wall at a depth of ten to twenty feet, most of the neighbouring residents prefer the lake empty. A succession of really wet seasons is necessary to fill the lake (Fig. 50), since the silt acts as a sponge, while the wind drives the water for miles over the lake bed, and thus evaporation rapidly removes any casual flood waters.

A little to the south of Lake George is a large valley with an absolutely **flat** floor. This is the **Molonglo Plain**, and it is probable that here we have a "buried" lake. After filling the depression—due to the same cause as in Lake George— the river Molonglo can now overflow to the west through a defile 150 feet deep.

The great Fault Scarp at Kurrajong Heights (Fig. 17), has given rise to a lagoon in a similar way, though on a much smaller scale than that of Lake George. This small depression, known as **Mountain Lagoon**, lies about thirteen miles north-west of

Richmond. The drainage of this depressed area has, however, been carried off by the Grose and other rivers, which, though deflected towards the lower southern portion of the fault scarp, have not been "beheaded" as in the case of the old Lake George River.

C. **Lateral Valley Lakes.**—**Lake Bathurst** is approximately circular, with a diameter of about three miles. It lies ten miles to the east of Lake George, and about twenty miles south of Goulburn. The lake is surrounded by hills two or three hundred feet high, composed of hard quartzites, except on the north, where a belt of coarse granite occurs. Spurs of the latter rock project into the lake and have determined the existence of Rabbit Island, which rises above the lake level some thirty feet. Very occasionally the lake overflows at the gravel pits on the west side and reaches its old

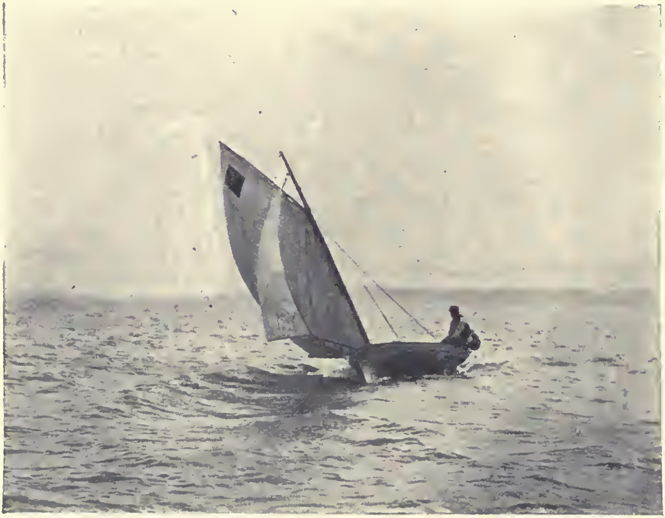

Fig.50. Lake George after a succession of wet seasons.

outlet, Mulwaree Creek. The latter ultimately joins the Wollondilly at Goulburn. Its flood periods very naturally agree with those of Lake George, and it is stated that in 1874 the lake trickled over into Mulwaree Creek. Again in 1890 the lake was very full, and residents of Goulburn were dreading a probable flood as the result of a further rise.

The Mulwaree rises about eight miles south of Tarago and flows to the latter along the foot of steep hills of quartzite. These are characterised by immense quantities of "talus" or rock waste, which is carried north by the Mulwaree and redistributed on its banks lower down. Formerly in times of greater rainfall it would appear probable that a stream entered the Mulwaree from the east near Tarago and drained the present Lake Bathurst basin. The **silt and rubble** of the present stream apparently blocked the narrow lateral valley, perhaps only temporarily at first, but gradually becoming too strong for the diminishing supply of the tributary. Finally a large shallow lake was formed, somewhat in the same way as marine lagoons arise, through the influence of wind on the sand at the mouth of the shallow bays. There is, however, a strong probability that a slight manifestation of the **folding** and faulting seen in the adjoining basin of Lake George has also affected the Lake Bathurst basin. This may have initiated the damming of the waters, which would then be completed as described above.

This lake also received deposits of silt and rubble. many talus fans being visible along the south-west shore, and these were driven about by the wind and waves, gradually being piled up at the angles of the lake. Such shingle and gravel deposits occur chiefly at the western and southern corners of the lake, and resemble in form the wind and wave driven structures known as "clinker banks," which are so characteristic of coral reefs. Hence the lake has to a certain extent formed its own barrier.

Although Lake Bathurst is only about one-tenth the area of Lake George, the former is not often perfectly dry. This is owing probably to the lake bed being more irregular, so that the water can collect in deeper pools. The water was fresh enough late in 1905 for tortoises, but gradually became too brackish, and thousands of these reptiles were compelled to search for more suitable habitation. Unfortunately for them all the creeks near at hand were dry, and in February, 1907, the eastern shore was littered for over a mile with hundreds of carcases of tortoises, which had died towards the end of 1905. Many sea gulls frequent the water, which in the month just mentioned was a foot deep, but was surrounded by a zone of sticky noisome mud. The outer portions of the lake are covered with thistles and grass, and sheep now pasture where regattas and swimming carnivals have been held. When the lake is a "banker" it extends to the north-east and occupies the Bonnie Doon Lagoons. At such periods a large portion of it must approach thirty feet in depth.

D. **Lakes of the Interior.—Lake Cowal** is situated about forty miles south-west from Forbes, at the foot of the western slope, where the hills merge into the great western plains. The lake bed is about eighteen miles in length and about three in width; but like most other Australian lakes, it is dry over a considerable portion during long periods. From 1870 to 1882 the lake was full; the biggest recorded flood occurred in 1870. Under normal circumstances the only inflow is at the southern end, along Bland Creek and other streams flowing near Marsden. The water carried down these creeks never has any great effect on the lake waters. The latter depend almost wholly on the **floods of the Lachlan.** This is significant of the origin of the lake. About twenty miles west of Forbes the Lachlan passes through a water gap, Jemalong Gap, and is here several feet higher than the bed of Lake Cowal (671 feet above sea level). During times of flood the water spreads over miles of country to the south of its normal course, and finally finds its way into Lake Cowal on its eastern shore (see map Fig. 51.)

During 1891-2 several floods, due in part to the melting of snow at the head of the Lachlan, found their way into the lake, and filled it up to the level indicated on the map. The lake is deepest at the southern end, farthest away from the outlet by Manna Creek, and no overflow occurs till some ten feet of water has run into the lower lake near Marsden. Finally the overflow gradually reaches the Lachlan about forty miles below Jemalong Gap.

A possible explanation, recalling that given for Lake Bathurst, is that the increasing aridity of the west during the last cycle of climate, has led to the dwindling of the tributary streams running into the Lachlan, *i.e.*, Bland Creek, etc., so that these are no longer able to scour their channel. The main stream, the Lachlan, has, however, a much greater catchment area, and carries down large quantities of silt, which it deposits on reaching the plains. Gradually **its bed is built up,** blocking the inflow of the tributaries. The latter carry comparatively little silt, so that their beds remain approximately at the old level. Any extra supply of water in the main stream is able to escape from the self-made elevated channel, and reaches these surviving lower depths in the tributary stream. In much the same way the Colorado River in the south-west of the United States of America has dammed off a lateral tributary and given rise to the Salton Sink or Lake. Here also the Colorado River is now higher than the old tributary bed, and occasionally devastating floods ensue, when the river breaks away into its old tributary's channel.

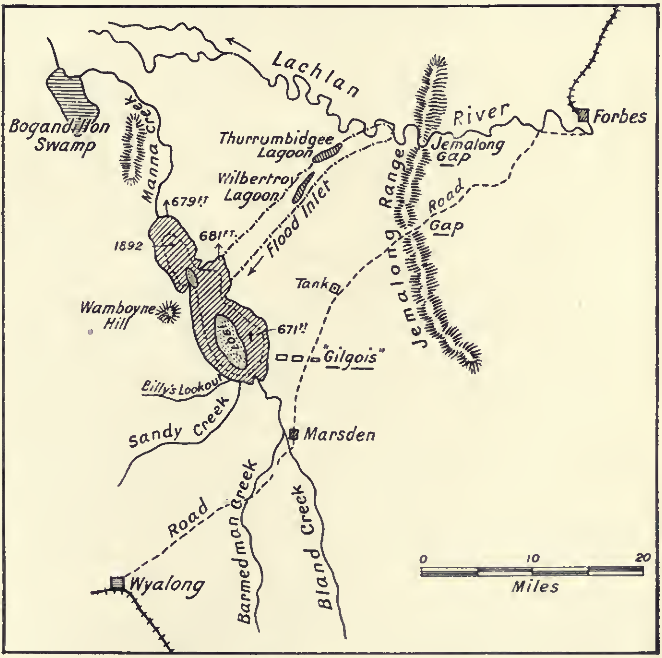

Fig. 51. Map of Lake Cowal, N.S.W.

In the United States of America advantage has been taken of the difference in level to irrigate the valley of Salton Sink with water from the Colorado, and a similar scheme has been suggested for Lake Cowal. The latter presents an uninviting appearance, the bed of the lake being occupied largely by dead trees. Early in 1907 the lake was represented by an area of shallow water, in its lowest portion, two or three miles long.

An interesting feature of the western country near Cowal and elsewhere is the presence of "**Gilgis**" (**Coolamon Holes** or **Gilgois**). These are basin-shaped depressions in the black clay, and often occur in rows of three or four running east and west. These sand-filled hollows collect the rain water, and are usually crowned by large gum trees in consequence. Their origin is undecided. One theory surmises that they are huge sun cracks in the mud which have been silted up with sand; another is that they are the relics of ancient springs from which sand welled up much as mud does in our mud springs of to-day. Another explanation* is that they are surface indications of a **deep alluvial channel**; the water flowing in the latter gradually removing the support of the overburden, which then subsides and cracks, allowing the surface to sag in the hollows from point to point. Probably the best explanation of the origin of Gilgis is that given by Mr. E. F. Pittman, Assoc. R.S.M.,† viz., that they were hollowed out by the circular whirlwinds known as Willy-willys or Burramuggas so common on the western plains in summer.

Of importance from an economic point of view is the series of lakes, some of which are indicated in Fig. 51 above. They probably originated in much the same way as Lake Cowal.

D. J. Gordon, in his admirable pamphlet, "The Nile of Australia," gives an account of several lakes, of which there are stated to be seventy on the Darling alone. (Fig. 52). He remarks:—"These are lakes which,

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*Due to Mr. E. K. Hall, B.E., of Coolamon.
†Pittman, E. F., Mineral Resources of New South Wales, p. 465.

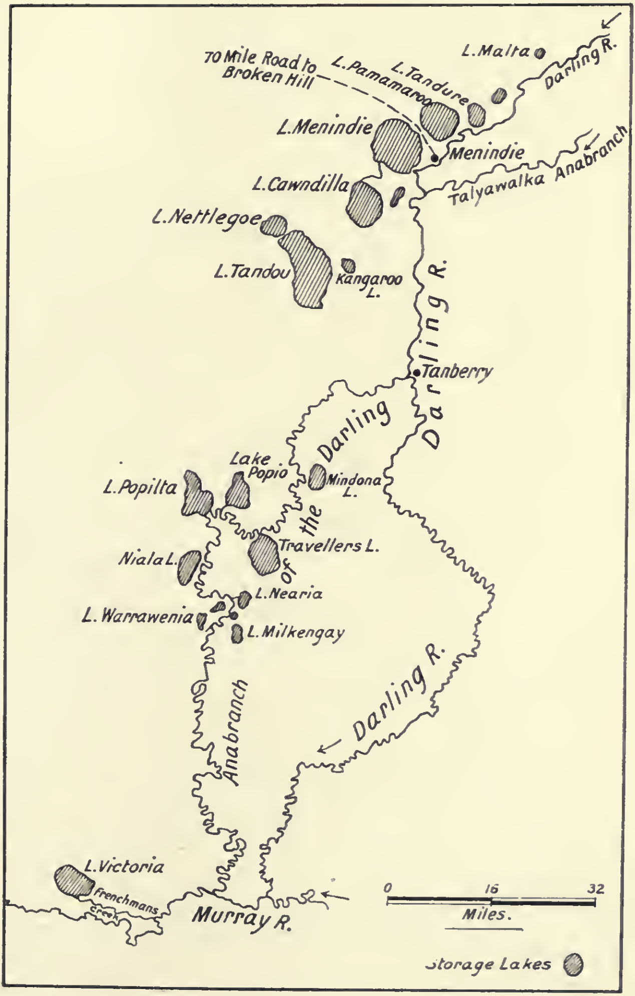

Fig. 52. Storage Lakes of the Darling.

when filled, are more like inland seas than anything else. Take **Lake Victoria**, for example. It is situated fifty miles beyond the South Austrálian border, and is in New South Wales. The physical features of the country assume the form of a basin. During flood time the water pours into this, and covers an area of 30,000 acres to a depth that gives 17,000,000 cubic feet of water. Lake Victoria is fringed by well-grown gum trees, whilst the country surrounding it is typical of inland Australia. Mr. Shannon, the manager of Lake Victoria station, states that he has seen the outflow from the lake keep the river navigable to South Australia for four weeks after it had been closed above the Rufus. In order that full advantage might be taken of such floods, the lake could be filled by raising the river level below Frenchman's Creek, and diverting through it to Lake Victoria.''

Lake Menindie, considerably to the north of Lake Victoria, on the Darling, after having been filled by flood waters, has been observed to maintain navigation in the Lower Darling for many months after it had ceased higher up the river.

CHAPTER X.—COAST LINES.

(W. G. WOOLNOUGH, D.Sc., F.G.S.),

In the study of coast structure it is essential to distinguish between the local forms developed, and the general character and trend of the shore. The former are expressions of local variations in hardness and stability of the rock masses, the latter depend upon the broad geological structures of the region.

The **dominant factors** in determining the features of a coast line are subaerial and marine denudation, geological structure, and the position from time to time of the sea-level.

Under subaerial denudation we have to consider the effect of erosion and deposition principally as affecting the development of peneplains and deltas. It has been shown elsewhere (Chapter VI., p. 43) that, if a continental area remains without uplift or depression for a long period of time, the agents of subaerial denudation cut down its surface to a gently undulating plain, which slopes gradually from sea-level near the coast to insignificant altitudes at the main divides. These latter are ill-defined if the process of denudation has been carried to completion. Hand in hand with this process of erosion, accumulation of material takes place, both upon the land surface, as flood plains, subaerial deltas, etc., and below sea-level as subaqueous deltas, estuarine and marine sedimentary formations.

The striking nature of coast scenery might suggest that marine erosion is the most important sculpturing agent in nature. It is no doubt very potent, but it is by no means the most efficient of such agents.

Examination of shore lines reveals a tendency for hard rocks and strong structures to be left standing as headlands, while soft rocks and unstable structures are eaten back to form bays and inlets. Although this is so, it does not necessarily follow that coast lines which have been long exposed to marine erosion are most irregular: on the contrary, such coasts are generally fairly regular. The rapid retrocession of the softer belts does not go on indefinitely; as soon as they are cut in some distance, the jutting headlands of hard rock protect them from wave action in all but directly onshore winds. Until the protecting headland is worn away, marine erosion of the soft rocks is reduced to a very small value. Original inlets deeper than those formed as above explained are not only immune from marine erosion but are actually filled up by the sediment, marine and terrestrial, washed into them. The accumulation takes place chiefly at the head of the bay, whose shore line is thus advanced until it comes to a position where marine erosion just balances reclamation. (Fig. 53).

It is therefore important to recognise that coast lines as we know them are the result of a more or less protracted action of all the forces of nature, constructive and destructive, tending towards a condition of equilibrium.

Wave action is not confined to that portion of the earth's crust projecting above sea-level. Waves and currents combined exert their influence to some depth below the surface, though the effective limit of such action is surprisingly small. Slight erosion extends to a depth of perhaps a hundred fathoms, but marked wear and tear is not shown by electric cables at depths greater than about 20 fathoms. As a result of this, the reduction of level of the land has a lower limit; and old coast lines are generally fronted by a broad or narrow submarine platform or "plain of marine denudation,"* over which the water is comparatively shallow. Such a platform is called the "continental shelf." There is generally a marked break in the continuity of the submarine profile at about the 100 fathom line, from this point to the abyssal depths of the ocean the slope is steep.

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*Chap. vi., p. 43.

If the ocean currents over the continental shelf are strong it may be kept fairly free from accumulations of detritus; where strong currents are absent, it is likely to become thickly covered with a layer of sedimentary deposits. These tend to tone down its irregularities and reduce it to a uniform gentle slope oceanwards.

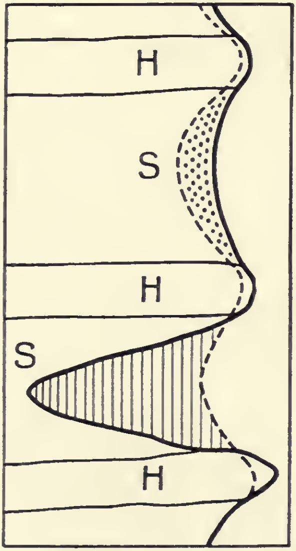


Fig. 53. Coast Series. H=Hard rocks. S = Soft rocks. The original coast is shown by the heavy line, the coast formed by the adjustment of erosion and deposition by the broken line. The dotted area represents rock washed away by wave action, that shaded by vertical lines the part built up by accumulation of sediment.

Given a sufficiently long period of time without movements of uplift or subsidence of the land, hard and soft rocks alike become cut down to base-level; but this stage of development is rarely attained. Usually the land surface is either uplifted or depressed, before its roughnesses have been removed in this way.

In the earlier stages of erosion, the geological structure of the land exerts a very marked influence on the form of the land surface. Hard rocks tend to stand out as hills, softer ones to be worn away into valleys and plains. During a very youthful stage the rivers form deep narrow valleys, which gradually open out as erosion approaches maturity.

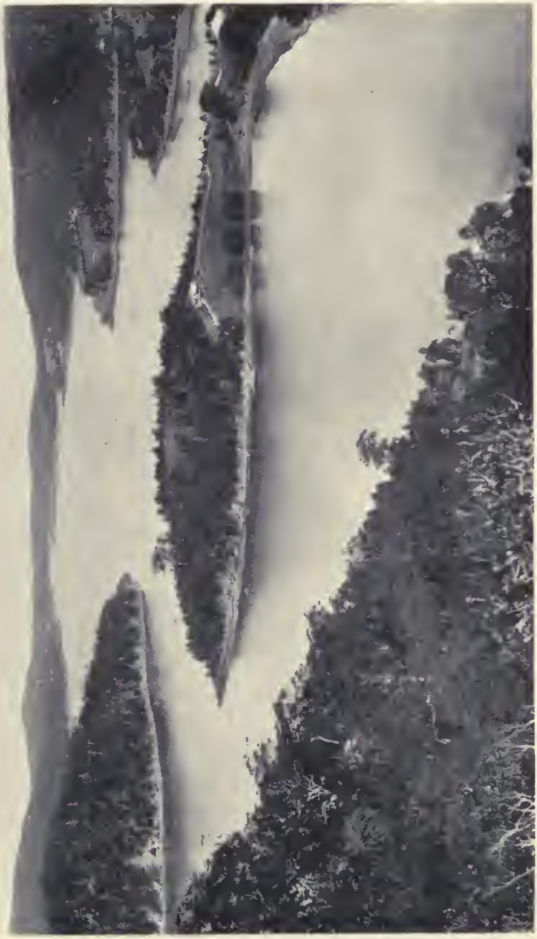
Moderate **elevation** of a country which has reached maturity of erosion causes the emergence of part of the continental shelf, which forms a broad or narrow **coastal plain**.

If the shelf is a plain of marine erosion, it is likely to be somewhat undulating: hence the new coast line may be somewhat indented; but, as the relief of the shelf is never great, the indentations cannot be very marked. There is a gradual slope from the old coast line, now inland, to the new coast and thence below water-level. Wave action will be a considerable time in cutting out a new shelf and producing a line of coastal cliffs.

If the shelf is a plain of accumulation, it is likely to be very even; hence the new coast, produced by uplift, is devoid of indentations and is fronted by shallow water and a shelving bottom. The sediments exposed by such a movement, are uncompacted, so that they are readily denuded, both by stream and wave. A line of cliffs will be rapidly chiselled out, and rivers will quickly scour deep valleys, whose mouths will form harbours.

Accumulations of sediment take place chiefly opposite river mouths. On moderate elevation of the sea bottom these mounds of sediment may be lifted above the water, and may form sand-banks and islands parallel to, and not far from, the coast. Inside these sand-bars lagoons may be enclosed, as on the east coast of the United States.

Moderate depression of a region of youthful topography causes the sea to flow into the lower valleys of the streams, drowning them. (Fig. 54). The whole of the trunk portion of a river system may in this way be flooded, and the system is "betrunked." The



Tourist Bureau

Fig. 54. Newport Pittwater: part of a Drowned Valley of the Hawkesbury Estuary.

branching drowned valleys thus converted into arms of the sea become magnificent harbours, though their steep sides are not eminently favourable for settlement.

The lowering of the floor of the continental shelf deepens the water there, so that there is deep water right up to the shore line.

Such a coast line is the most indented type imaginable. It is not so likely to yield islands as the next kind.

A region of early maturity of erosion depressed below sea-level yields a coast characterized by broad sweeping bays with curving shore-lines, shelving bottoms, and numerous off-shore islands. The bays represent the drowned U-shaped river-valleys, and the islands the unsubmerged remnants of older peneplain levels.

The submergence of a land surface far advanced towards maturity of erosion yields a coast somewhat resembling that formed by elevation of a similar area. The drowned peneplain possesses few irregularities to cause the formation of inlets or of islands, so that a monotonous, even, shelving shore is produced.

These indicate only a few of the infinite variety of types of shore evolved by the processes enumerated above.

The first impression with regard to the outline of the coast of New South Wales is its extreme uniformity of trend. The general direction is N.N.E. to S.S.W., and there is scarcely an important departure from this general line. Between Port Stephens and Trial Bay there is a considerable bulge in the coast, and the shores of Jervis Bay form a local projection, but otherwise the average direction is strikingly preserved. This trend is so nearly parallel to that of the axis of the

Main Dividing Range that a connection between the two structures is at once suggested.

A second remarkable characteristic of the shore line is the number and complexity of outline of the inlets. In the central third of the coast the character of these inlets is especially remarkable. These are wonderful bays with deep water and steep rocky shores; they owe their existence to the submergence of a partially dissected plateau. There is abundant evidence to show that during late geological time there have been successive uplifts of the land (aggregating at least 7,000 feet), with intervening periods of repose during which the country was more or less completely worn down by river action. At the close of the latest cycle of erosion there was a general subsidence amounting to at least 400 feet in the central portion of the area. This caused the "drowning" of the valleys of the coastal rivers, and the conversion of these drowned valleys into magnificent harbours.

Three inlets near Sydney afford a very instructive comparison. These are Broken Bay, Narrabeen Lagoon and Port Jackson. All alike are drowned river-valleys, but the action of other physiographic forces has produced very notable differences between them.

In the case of Broken Bay, one of the most important of our coastal rivers (the Hawkesbury) flows into it. This stream brings down enormous loads of sand and mud, a large part of which it deposits in the still waters of the numerous arms of the bay. Many of these inlets are therefore much silted up, as pleasure seekers find to their cost. The river has a powerful current, which, assisted by the tides, possesses a sufficient "scour" to keep the main channel clear of sediment. The detritus is carried out through the heads, and far enough out to sea for the shore current to sweep it clear of the outlet. The result is, a great inlet with an open mouth and clear fairway, but very much silted bays.

Into Narrabeen Lagoon flows a rather insignificant stream, whose watershed is of sufficient dimensions to supply a large quantity of detritus during wet seasons, but the stream is not strong enough to push this material well out to sea as does the Hawkesbury. When the river current meets with the "dead water" of the coast, it deposits the bulk of its burden. By degrees this accumulation has attained considerable dimensions. It has been piled up to high-water level, and by the combined action of wind and waves has formed a bank high and dry. On this vegetation has taken root and now serves to hold the shifting sand. For most of the time the bank produced in this way completely or almost completely closes the mouth of the lagoon, the fresh water from the creek finding its way into the ocean through the porous material of the sand bank. In very wet seasons, however, the stream breaches the bank and forms a temporary opening to the sea. The lagoon itself is shallow and littered with shoals.

Port Jackson is an inlet of the same order of size as Broken Bay, and, like it, possesses an extremely irregular coast line. It is very much larger than Narrabeen Lagoon; in fact, many of its tributary bays exceed the total size of that valley.

Unlike Broken Bay, there is no effective river flowing into it; hence very little silt is introduced into its waters. Most of the arms of the harbour are, therefore, practically free from sediment, and have deep water right up to the rocky shores. The reason why no river nowadays flows into the head of this great bay is that George's River has beheaded the original stream flowing into it, leaving only the insignificant trickle of Duck River to enter the harbour.

Spacious as many of the coastal inlets are, comparatively few of them are eminently suitable for harbours. Either navigation is impeded by shoals, as in the case of Port Stephens and Botany Bay; or the entrance to the sea is partially blocked by **sand bars,** as at Lake Macquarie, Wallis Lake and Camden Haven; or completely enclosed by similar obstacles, as at Lake Innes. In many instances the "Lakes" are opened occasionally by natural or artificial means.

An examination of the map indicates that with one exception (Broken Bay) the large indentations and "Lakes" have either no river flowing into them or possess at most a very insignificant watershed. Conversely, the larger coastal rivers have mostly narrow entrances, backed by a network of channels winding through low-lying deltas.

The exception which goes to prove the rule is the Hawkesbury River. (Fig. 55). Flowing through a fairly lofty plateau of solid, structureless freestone, it has not been able to do more than gouge out a narrow channel, whereas more favourably situated streams like the Hunter and Northern Rivers have excavated broad mature valleys. When the subsidence occurred, the restricted nature of the Lower Hawkesbury kept up a scour as noted above.

The submerged mature valleys formed wide open bays in which the water was "dead" and out of reach of the great north and south current, called by Hedley the "Notonektian" current.*

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*Proc. Linn. Soc. N.S. Wales, vol. xxxv., 1910, p. 9.

Under these conditions deltas formed rapidly and were pushed forward until they reached a line joining the headlands north and south. Beyond this line they were unable to extend, on account of the wash of the current. There is an entire **absence of great projecting deltas**, like that of the Mississippi, for this reason. Since the completion of the delta formation there has been a slight, but general, **uplift** of the coast line, which has very materially assisted in the reclamation of vast areas of rich agricultural land; the swampy delta surface has been lifted from five to fifteen feet and, thereby, naturally drained.

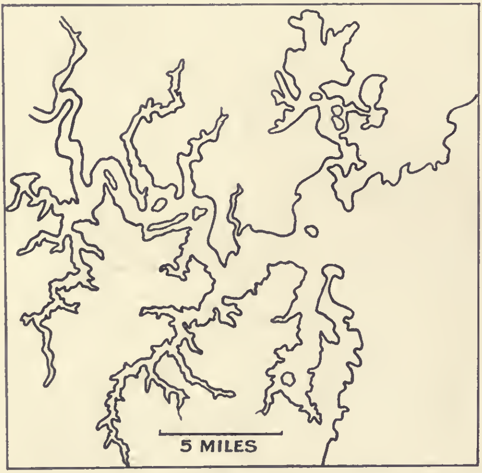

Fig. 55. Broken Bay—the Estuary of the Hawkesbury River.

In the Hunter Valley* at Largs, and at Farley, still further inland, there occur "raised beaches" containing subfossil shells belonging to species existing at the present day.

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*David, T. W. E., The Geology of the Hunter River Coal Measures, New South Wales, Memoir (Geol. No. 4) Geol. Surv. N.S.W., 1907, pp. 71 and 283.

These raised beaches stand as much as fifteen feet above sea-level, and mark the amount of uplift of the land in recent times.

Further north, in the region round the Myall Lakes, Smith's Lake, Wallis Lake, the Manning and Camden Haven, there is an enormous stretch of similar upraised delta deposits. (Fig. 56). In the Illawarra district evidence of this uplift is afforded by the occurrence of a very well-marked and fairly continuous wave-cut platform fronting the cliffs.

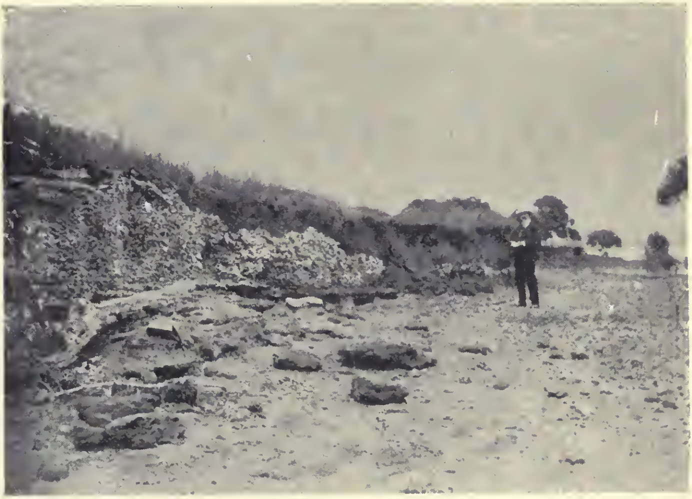

Fig. 56. Raised Shell Bank on Cattai Creek, Manning River 6ft. above high water mark (springs).

A peculiar feature of the tidal portions of most of the North Coast Rivers is their very marked **recurving** near their mouths. This is especially conspicuous in the case of the Richmond, Clarence and Macleay. For at least part of the length of the seaward end of the hook the streams are separated from the ocean only by low and narrow sand spits, very similar in structure (and therefore probably in origin) to that described above in the case of the Narrabeen Lagoon. In some instances these spits become broken through by heavy floods (as, for instance, at the Macleay in 1895), and new and improved entrances are produced thereby. In the case of the Manning the recurved portion of the river provides the principal entrance at Harrington, but the phenomenon is somewhat obscured by the occurrence of an older entrance much further to the south.

As already explained, **bars** are due to the combined action of ocean currents, and waves and winds, but considerable diversity of opinion exists as to the exact part played by these two agents. The shore current flows chiefly from north to south, and the prevailing wind on the coast is north-easterly. The westerly winds of winter are almost non-effective in the matter under consideration, their main result being to drive the current somewhat off shore. But while the prevailing wind is north-easterly, the most powerful gales come from the south and south-east. When such gales blow, sand movement is at its maximum, and when they continue to blow for some time they not only arrest, but even reverse the coastal current. It is a moot question whether or not the long-continued moderate action of the prevailing winds and currents is more effective in sand transport than the paroxysmal force of the great southerly storms.*

†A definite relationship has been shown to exist between the distance separating two adjacent headlands, the amount of their projection beyond the general

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*Andrews, E. C., An Introduction to the Physical Geography of N.S. Wales, Sydney, 1905, p. 76.

†Halligan, G. H., Sand Movement on the New South Wales Coast, Proc. Linn. Soc. N.S. Wales, vol. xxxi., 1906, pp. 619-640.

line of the coast, and the curve of the sand beach between them. This curve resembles the long portion of the Greek letter ζ, and is therefore called by Halligan the "**zeta" curve**. He explains its formation as due to the production of recurving "eddies" in the shore current as it sweeps past projecting headlands.

In the south many of the lagoons and inlets partially closed by bars have entrances near the northern of the two headlands limiting them; but, as Halligan points out, this is not a universal, nor even a predominant characteristic. The drift of the sand, and, therefore, the position of such entrances as these, are probably very largely influenced by the local contour of the coast line.

If Halligan's very elegant theory of sand-drift is found by practice to hold good, the application of his "zeta" curves will have a very important economic bearing in settling the vexed question of the positions and dimensions of artificial **breakwaters** necessary to control the sand movement at the mouths of our coastal rivers. These streams, with their rich alluvial flats and thriving settlements, are becoming an increasingly important factor in the industry of the State, and the solution of the difficult problems of bar-prevention or control is one of the most pressing economic questions in the country.

Another type of coastal inlet deserves mention, namely, the **sea-cut bay**. These are not of great extent or importance. They owe their existence to local differences in hardness of the rocks of the shore. Examples near Sydney are Long Bay and Little Bay, which are due to the lines of weakness caused by volcanic dykes running at right angles to the coast.

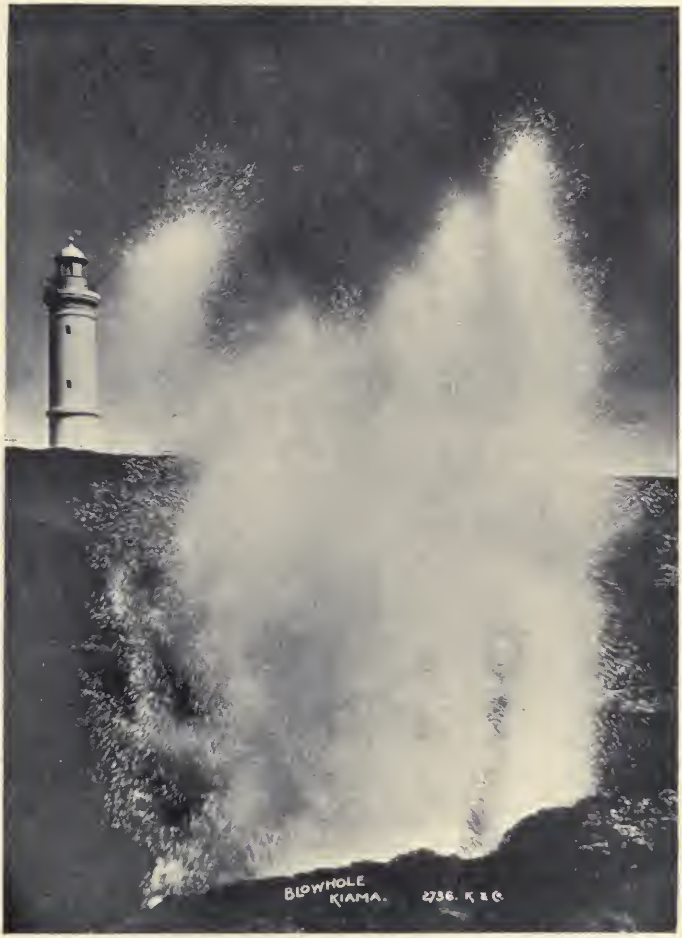
Geologically the coast line may be divided into **eight fairly distinct sections.**

From Cape Howe to Bateman's Bay the rocks are chiefly ancient slates, much contorted and jointed, with large areas of intrusive granite at intervals. The coastal plain is narrow, and often intersected by spurs of the main plateau coming right down to the shore and forming steep rocky promontories. Here the coast is rugged, and there exist sea-cut islands and reefs, as, for instance, just south of Bateman's Bay. Certain of the granite areas have withstood the wear and tear which has removed the weaker sediments, and remain as rocky islands off the coast, for example, Montague Island.

The Coast Range is close to the shore; therefore no rivers of very considerable size enter this part of the coast. The forms of the inlets and narrowness of the coastal plain suggest moderately deep submergence of a youthful dissected plateau.

The **second section** of coast extends from Bateman's Bay to Clifton. It is in very marked contrast to that described above. The rocks consist chiefly of sediments with a very gentle inclination in a general northerly direction. These rocks belong to the great Permo-Carboniferous System, which contains our workable Coal Measures. The alternation of hard and soft beds, combined with their almost horizontal arrangement, favours the development of vertical cliff faces. Such structures are of frequent occurrence all along the stretch under consideration.

The most striking feature of this part of the coast line is Jervis Bay, whose two precipitous headlands jut far beyond the general line of the shore. They owe



Kerry & Co., Sydney.

Fig. 57. Blow Hole, Kiama.

their preservation to the existence of an extremely hard bed of rock, known as the Nowra Grit, which outcrops at this point.

At Kiama there is a great development of volcanic rocks. These are much jointed, so that, in spite of their intense hardness, they yield weak structures. Characteristic denudation has produced islands like the Cathedral Rock. The wonderful Blow Hole at Kiama is due to the undercutting of the hard upper portion of the lava-flow by the waves, and the production of a funnel by collapse of the roof at the inner end of the tunnel so produced. (Fig. 57).

Near Wollongong the Coal Measures proper put in an appearance. At Jamberoo and Cambewarra the principal coal seam is some 1700 feet above sea-level. Thence it falls northwards, until at Clifton it reaches sea-level.

The only large river in this piece of coast line is the Shoalhaven. In that portion of the shore where coal is developed there are no good natural harbours. The cliffs are fronted by a broad sea-cut shelf, part of which lies between tide levels.

The **third section** of coast extends from Clifton to Lake Macquarie. Like the portion just described it is built up of almost horizontally stratified sedimentary rocks. These are younger, geologically, than the Coal Measures, and yield a frowning wall of cliffs broken here and there by the narrow entrances to spacious bays, or by stretches of sandy beach. The uppermost coal seam reaches its maximum depth below the surface (about 3,000 feet) just under Sydney. It is a coincidence that in the second section of coast we have coal and no natural harbours, while in this third portion we have natural harbours, but the coal lies at so great a depth as to make its exploitation somewhat costly. The only considerable river entering this stretch of shore is the Hawkesbury.

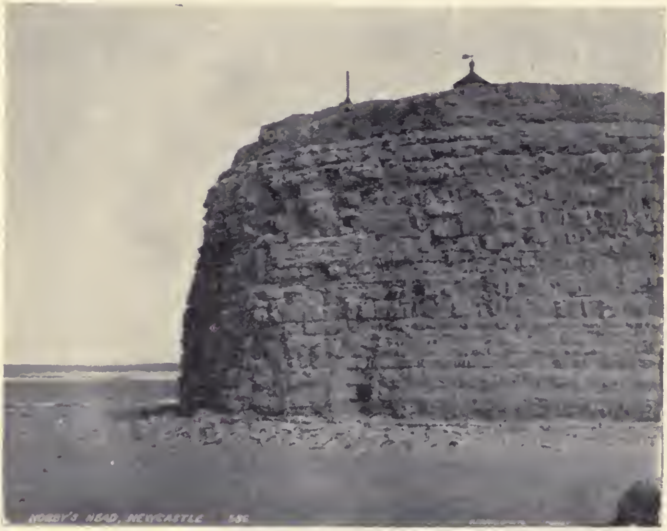
The **fourth section** lies between Lake Macquarie and Port Stephens. Geologically it resembles the second section in consisting chiefly of Permo-Carboniferous rocks. These dip southwards and form the northern lip of a great earth-basin which passes right under Sydney and reappears in the second section of this coast. This topmost coal seam reaches sea-level a short distance from Catherine Hill Bay, and, between this and Newcastle, we see all but the lowest coal seams of the Upper (Newcastle) Series, exposed in the cliff sections.

Lake Macquarie is a splendid sheet of deep water, but its entrance is almost impracticable. The estuary of the Hunter forms the Port of Newcastle. Nobbys, lying off Newcastle, is a very striking structure. (Fig. 58.) It is, or rather was, a sea-cut island, owing its preservation to the action of volcanic dykes in hardening its rocks. The building of a breakwater has caused the formation of an extensive sand spit joining the island to the shore.

Northwards from Newcastle stretches Stockton Beach, backed by the low-lying alluvial land forming the delta of the Hunter.

From Port Stephens to Trial Bay we have the **fifth section** of the coast. It consists for the most part of hard, somewhat ancient sedimentary rocks, considerably tilted and folded, though not to the same extent as those in the first section. The degree of hardening of these rocks, and their freedom from excessive jointing, has caused them to wear better than any others along the coast, with the result that this part of the shore line forms a marked bulge, as noted above. High rocky headlands alternating with long stretches of low-lying shore are characteristic here.

Another peculiar feature is the occurrence of a stretch of low-lying country parallel to the coast, behind the headlands. Much of this is submerged, forming a chain of lakes of wonderful beauty, such as Myall Lakes, Smith's Lake, Wallis Lake, and the lakes near Camden Haven. The Manning, Hastings and Macleay Rivers all belong to this section of coast.



Kerry & Co., Sydney.

Fig. 58. Nobby's Head, Newcastle. The tunnel at foot of cliff is on the Nobby's Coal Seam. The Borehole Coal Seam has been worked here 150 ft. below sea-level.

From the mouth of the Macleay River to a point somewhat north of Woolgoolga stretches the **sixth section** of shore line. This is very similar to that first described. The Coast Range is, in general, rather near the shore, which is rugged and looks out upon a number of sea-cut islands like the Solitaries and those which enclose Coff's Harbour. Two small rivers, the Nambucca and the Bellinger, enter the sea in this section.

The **seventh division** is similar in geological structure to the third in the fact that it consists of almost horizontally disposed rocks of approximately the same geological age. The sea cliffs are less imposing than those of the Sydney area, though of the same general type. The back country is fairly flat, and occasional basaltic hills, the plugs of ancient volcanoes, afford another feature of resemblance to the third section. Mt. Elaine, south of Grafton, is an example of such a basalt neck.

In this area two of the most important of the coastal rivers find their way into the sea, namely, the Clarence and the Richmond. Both are large streams with extensive, and very fertile river flats. Unfortunately both have bars at their mouths, so that navigation is thereby impeded, though not to the same extent as in most of the other coastal streams.

Just north of Richmond River and thence to the Queensland Border there is a reversion to the Bellinger-Woolgoolga type of coast. The rocky headland of Cape Byron projects sufficiently far to protect the open roadstead behind it from southerly storms, and forms an outlet for the rich dairy country behind. A good deal of basalt also occurs along this **eighth section** of the coast.

CHAPTER XI.—EARTHQUAKES.

(T. G. TAYLOR, B.A., B.E., B.Sc.)

New South Wales does not lie within the great belt of earthquakes and active volcanoes. Nevertheless the effects of these phenomena may still be noticed in our State, and small earthquakes are not uncommon along the main mountain axis.

In the first place there is not necessarily, nor even usually, any connection between earthquake shocks and volcanic action. An earthquake may be described as an attempt on the part of the earth's crust to attain a state of greater equilibrium, or, in other words, it is a slipping down of part of the earth's surface, often along some old concealed fissure, or fault, due to the continued shrinkage (secular contraction) of the outer cooling zones of the earth. If the cracking and rupture accompanying such movement are of sufficient magnitude they may reach down to zones of highly heated and compressed rocks. The cracking and faulting relieving some of this pressure, may allow the heated rocks to liquefy and rise to the surface, thus leading to volcanic action; but in the vast majority of cases no volcanic action accompanies a great earthquake. On the other hand violent volcanic action is often accompanied by earthquakes; as one would expect, the violent explosions of gas and steam cause the earth to tremble.

In New South Wales the warping which has given us our Main Dividing Range is not yet finished. That this warping was for the most part very gradual is proved by the fact that the course of the ancient river has not been altered. The Nattai River leaves a broad valley at Mittagong and enters a gloomy ravine with walls several hundred feet high, showing that the cutting action of the river was able to keep pace with the elevation of its basin. The Nepean at Camden flows along flat meadows, and then suddenly enters the mountains by a gorge which has been compared to the Rhine above Coblentz. Here again we have an example of an "antecedent" river (*sup.* p. 92) implying fairly late changes in the shape of the earth's crust. But in other parts of the State the folding has been accompanied by huge cracks and landslips; such were undoubtedly accompanied by earthquakes on a grand scale.

The elevated area of **Ben Lomond** is stated by Mr. E. C. Andrews, of the Geological Survey, to be a huge block about 45 miles long, left in its original position while the surrounding country has dropped some 1000 feet. Similar cracking and subsidence have taken place in the Monaro district; and it is in districts like these that we may look for further manifestations of the earth-force, giving rise to earthquakes of greater or less intensity. At Cooma in 1901 a sharp shock was experienced, due to a readjustment of the earth's crust in that district. This region is specially subject to slight shocks, as we shall note in a succeeding paragraph.

The vibrations communicated to the earth's crust by far distant shocks, such as the **San Francisco** earthquake of April, 1906, are readily detected in Australia. Thus at Melbourne the seismograph indicated that preliminary tremors reached Australia at 11.34 p.m. and lasted till 12.9 a.m. Then a group of ten large waves appeared at intervals of about five minutes. Each wave indicated a distinct shock. The severest shock ceased at 2.33 a.m.

At Jenolan and Penrith shocks have occurred during the last few years. These are connected with the further movements of the crust which led to the Great Fold of the Blue Mountains. At **Kurrajong**, near Richmond, a splendid example of an ancient earthquake crack is situated. Professor David states (Royal Society New South Wales, December, 1902) :—. . . . "the folding force came from a westerly direction, and it pushed the strata eastwards forming the steep easterly slopes of the Kurrajong and Lapstone Hills: a slight fold, facing the west, developing to the west of this eastern monocline near Glenbrook. After the folding force had become less intense or had ceased, a fracture formed along this western fold, the **plateau to the west subsiding over 400 feet** as the result; while the development of the monocline at Mount Tomah depressed the western portion of the plateau by a vertical amount of about 250 feet." Subsequent denudation has removed the sharp edges of the earth cracks or faults, but the discontinuity of the sediments can easily be recognised, and the scarp forms a prominent feature in the scenery of the Blue Mountains.

Sometimes earthquakes are due to the slipping of sediments deposited on the "**continental shelf**" of a coast. These are of minor importance, though one of the chief Australian earthquakes, that of Adelaide in 1902, may have been due to the redistribution of the masses of sediment brought down by the Murray. At the same time it is possible that this earthquake was due to the sudden movement of the earth's crust along a fault plane.

Although no earthquake in New South Wales has caused much damage, yet 80 per cent. of such shocks as have occurred, have taken place in one small area of the State along the south-east coast (see Fig. 59).

This means that here the earth's crust is still shifting uneasily, and as we shall see in the chapter on rivers, here are the chief fault cracks of recent geological date, and here some of the most striking "accidents to rivers" have occurred. The "congestion" of the rivers in this area is quite striking. The drainage system has been compared to a telephone service "where every subscriber required a main line to himself." In a word, it is inefficient, and therefore transient. For Nature when left to herself distributes the river tributaries in a regular radial manner—and where this system does

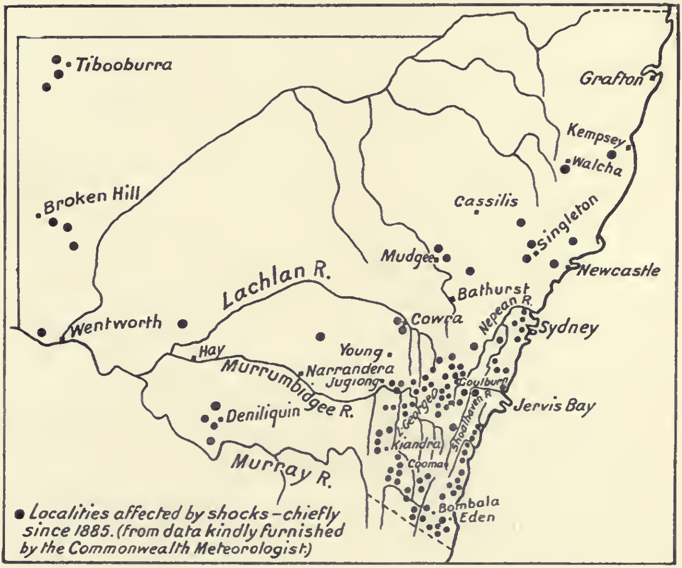


Fig. 59. Localities affected by Earthquake Shocks in N.S. Wales chiefly since 1885. (From data kindly furnished by the Commonwealth Meteorologist.)

Sketch Map showing the relation of the region of earthquake activity to the congested region of "meridional" rivers. The latter are "subsequent" to late faults and folds in the earth's crust.

not obtain—as in the south-east of the State—it implies a **recent and striking interruption** of her normal methods.

Hence it is tolerably certain that the peculiar directions taken by these rivers, the Upper Murray, the Mitta, the Snowy, the Upper Murrumbidgee, Tumut, Adelong, Goodradigbie, the Upper Lachlan, the Shoalhaven, the Wollondilly, and Nepean, are all correlated with ancient earthquakes of which we get slight reminders even at the present day.

CHAPTER XII.—ARTESIAN WATER.

(W. G. WOOLNOUGH, D.Sc., F.G.S.)

In the interior of New South Wales large areas possess an intensely dry climate. There is no permanent surface water, and, though water may be conserved in tanks and dams, it is subject to excessive evaporation, and is therefore likely to give out just when most needed. The discovery of an apparently perennial and inexhaustible source of supply is, then, a matter of the most vital importance. Such a supply, derived from subterranean sources, has been tapped in Australia, over a great part of Queensland, the north-western portion of New South Wales, and very large areas in central South Australia. (Fig. 61).

An artesian **basin*** consists essentially of a bed of porous rock sandwiched in between two layers of water-tight rock, one above and the other below, the whole possessing such an arrangement that when the upper impervious bed is pierced water rises above the ground level under **pressure due to natural causes.** When the

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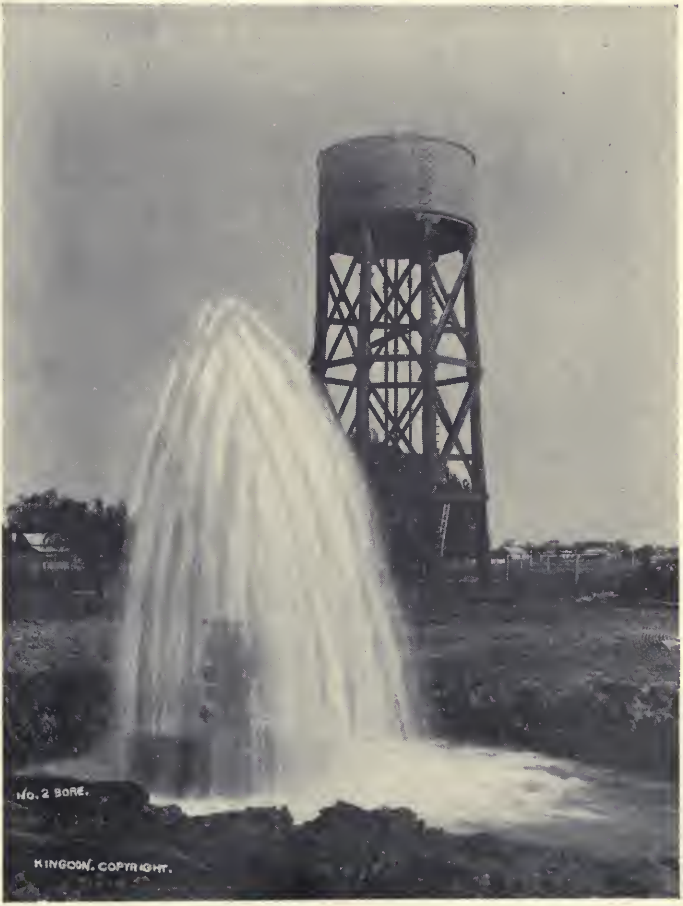
*Derived from Artesium Lat. for Artois, a province in France where wells of this kind have long been in use



Kingdon, Coonamble.

Fig. 60. Artesian Bores, Coonamble. No. 2 Bore in the foregroud, 2,180 feet deep yields 473,754 gallons daily. Temperature 101½° Fahr. The tank is kept filled by the water from No. 1 Bore, yielding 286,859 gallons daily.

pressure, though not sufficient to make the water overflow at the surface, is enough to raise it considerably above the level at which it was struck in the bore, the well is said to be **sub-artesian**. (Figs. 62 and 63.)

A number of **conditions** must be satisfied in order to produce a flowing artesian well. The **first condition** has been already defined, namely, the occurrence of porous and impervious beds interstratified. The **second condition** is that the porous stratum must be so placed as to receive a **supply of water**. In most, if not all, cases this condition is satisfied by the outcropping of the porous stratum at the earth's surface in an area of adequate rainfall. Rivers flowing across such a porous outcrop percolate into it and provide an abundant water supply. In some cases a stratum which does not outcrop at the surface may receive water through the intervention of another conduit intersecting it, and also reaching to the ultimate source of supply. A third conceivable origin for the water is plutonic*. It is known that igneous rocks, before solidification, contain large quantities of water dissolved in them. As the rocks solidify almost the whole of this water is given off. Enormous masses of granite have at various times

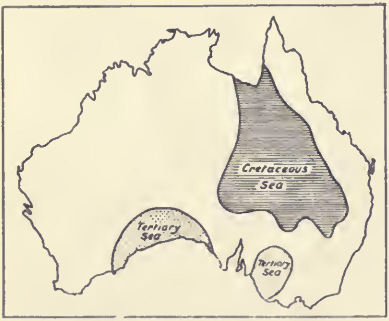


Fig 61. Map of Artesian Areas.

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*Derivation Pluto—God of the lower regions in Roman Mythology. Hence anything coming from great depths within the earth's interior.

been injected into the deep-seated rocks of the earth's crust, and some such masses below Central Australia have been invoked as the exclusive source of the artesian water supply.*

The **third condition** for the existence of an artesian basin is that the porous bed shall **be sloped or bent** in such a way that the water may flow, under the influence of gravitation† from the intake to the lower parts of the bed.

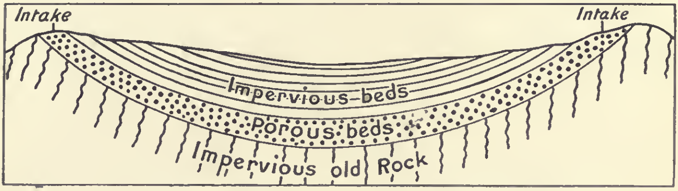

Fig. 62. Diagram of an enclosed artesian basin.

Fourthly, the porous bed must slope upwards at the end remote from the intake, must be stopped by abutting on an impervious formation, or, if open, must consist of material which offers a resistance to the perfectly free

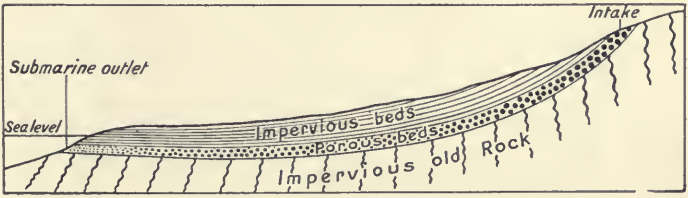

Fig 63. Diagram of an artesian open at both ends.

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*Gregory, J. W., The Dead Heart of Australia, 1906.
†Other possible causes of rise of water are gas pressure and rock pressure.

passage of the water. This condition is necessary in order that a sufficient **pressure** may be set up.

Fifthly, if a well or bore-hole piercing the upper impervious stratum is to have an artesian (naturally flowing) supply, the outlet of the well must lie below the "**hydraulic grade.**" This term needs some explanation. Suppose we have a tank (Fig. 64), with a pipe leading from it which is supplied with a tap at its far end and with vertical stand-pipes along its course. If the supply-pipe is everywhere below the level of the water in the tank, we obtain a flow on fully opening the stop cock, S. If we now examine the level of the water in the stand pipes P1, P2, P3, we find that it becomes successively lower the further the stand pipe is from the source of supply. A line through the water levels in successive stand pipes is called the hydraulic grade. If the frictional resistance to the flow of the water through the pipe between the tank and the outlet is evenly distributed, the hydraulic grade will be represented by a

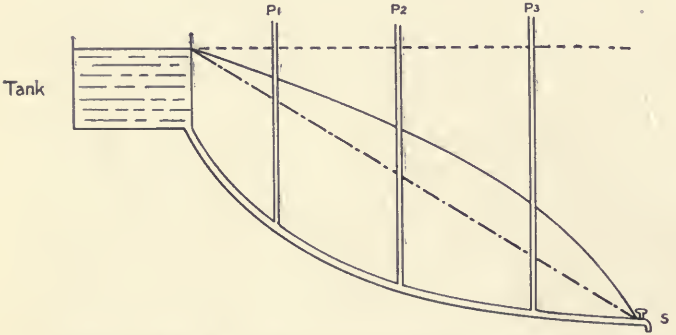

Fig. 64. Diagram to illustrate the flow of water in an artesian basin.

straight line from the water level in the tank to the outlet. If from intake to outlet there is a successive increase in the frictional resistance to the passage of the water, it will be found that the hydraulic grade will rise as indicated by the curved line. If one of the pipes is so short that its top lies below the level of the hydraulic grade, the water will overflow, and we shall have an illustration of an artesian well. If the stop-cock is shut, water will rise to the horizontal line marking the surface of the water in the reservoir.

In order that the water obtained from an artesian basin shall be fresh it is probably necessary that a **sixth condition** shall be fulfilled—that the basin shall have an outlet, in order that the water may circulate. If the water were allowed to stagnate for ages in a closed basin, it would certainly become very highly mineralized.

Let us now examine the **geological history of the Great Artesian Basin of Australia**, and see how these conditions have been fulfilled.

Shortly after the coal measures of the Hunter River had been formed, a period followed during which immense **fresh-water lakes** were developed in Eastern Australia. These were studded with islands, especially near the shore line. Into the depressed areas rivers from the land brought down their loads of sediment, and deposited the material on the lake floors. The land was fairly high and the rivers fairly rapid so that the sediment was coarse gravel and sand. The coarser material was dropped first, and the deposit became finer and finer in grain as the distance from shore increased. Each island contributed its quota to the mass of sediment, but, naturally, interrupted the continuity of the sheet. It is important to remember this last fact. The approximate extent of these lakes is indicated on the map (Fig. 65) by the dotted areas. From time to time during this lacustrine period coal-forming conditions returned; hence the porous pebble-beds and sandstones are associated with coal seams. **Earth movements** now became considerable, and the northern part of Australia was depressed, admitting the sea to the area now occupied by Western Queensland and parts of New South Wales and South Australia. A huge **Mediterranean Sea** was produced surrounded by high land on the east and south at all events. The process of wearing down of the land and deposition of land waste on the sea floor was repeated as in the preceding period. In this case, however, a bed of porous material was succeeded by an enormous thickness (upwards of 5000 feet in places) of fine-grained impervious marine clay beds. It is probable that the sea bottom was gradually sinking most of the time while deposition was going on. Most of the islands were completely submerged, and their tops hidden by sediment, leaving not the slightest visible trace of them at the surface.

The fresh-water sandstones are known as the **Trias-Jura** formation, while the marine beds succeeding them form the "**Rolling Downs**" Beds. The porous beds at the base of this formation are called the **Blythesdale Braystones.** On the map the latter are shown by cross hatching; the Rolling Downs beds are enclosed by a broken line.

The **uplift** and **warping** of the land brought the porous beds to considerable altitudes above sea level on the western side of the Main Divide, and exposed their upturned edges to the action of the weather. The volcanic action which accompanied these uplifts caused local injections of masses of heated rock through and amongst the sediments; and it is quite possible that, blanketed as they have been by enormous thicknesses of overlying rock, these injected masses may still retain considerable heat.

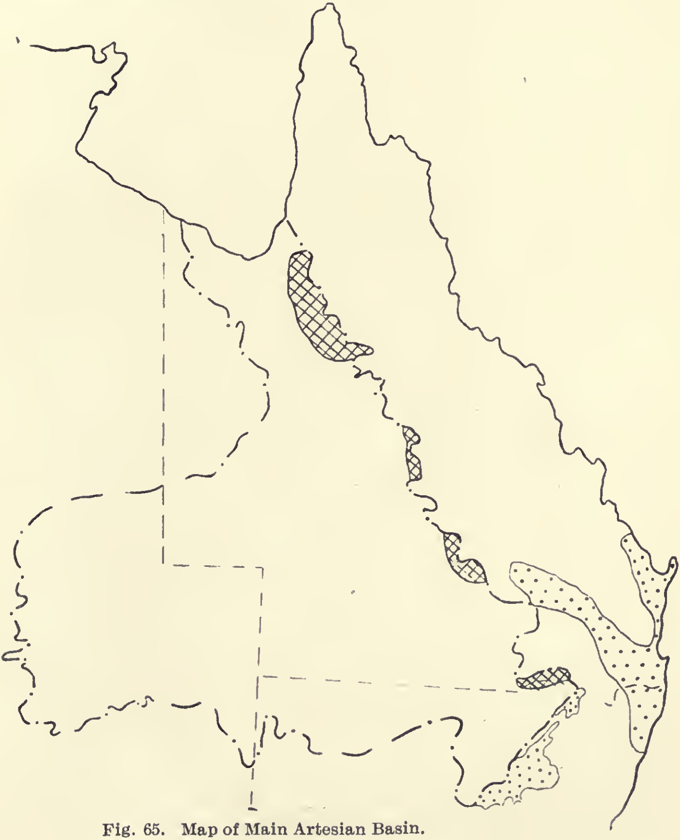

Fig. 65. Map of Main Artesian Basin.

As a result of this cycle of geological processes we have a basement of old, solid, non-porous rocks upon which rests a series of porous sediments, coarse near the old land surface, finer at a distance from it. These are capped by a thick series of fine-grained, impervious clays and shales. The whole of these rocks within New South Wales have a very pronounced tilt from south to north and from east to west. We have thus an **ideal condition** for the production of an Artesian Water Basin. The upturned and uplifted edges of the coarse sediments form the intake; the increasing fineness of the sediment causes increasing frictional resistance to the passage of water as we pass from the intake towards the outlet, and therefore produces a convex hydraulic grade. The impervious rocks above and below effectually seal down, and prevent the leakage of, the water absorbed at the intake; while the presence of an outlet keeps up a circulation and thus prevents extreme salinity of the water. The **porosity of the intake beds** is very great; it is recorded that a flooded stream, Torrens Creek, above the outcrop of the Blythesdale Braystones reached a horse's saddle-flaps but did not rise above the horse's knees at a point just below where the stream had crossed the outcrop of the intake beds. All the excess of water had been greedily sucked up by the porous beds. It has been estimated that, of the rivers of the Darling-Murray system, those southern ones which do not cross the outcrop of the Braystone **discharge about 8½ per cent.** of the total rainfall of their catchment areas. The remainder, neglecting minor sources of loss, is disposed of by evaporation and percolation. In the case of the Darling River **only 7 per cent. is disposed of by surface* flow.** Even granting an abnormally high evaporation, there is still a very considerable excess lost by percolation. It is estimated that the **porous intake beds*** **outcrop** at the surface over an area of about 18,000 square miles in New South Wales. Over this area there is an average annual rainfall of 25 inches, giving an available supply of 1,045,000,000 cubic feet of water a year. If only one-fifth of this finds its way into the exposed outcrop of the intake beds we have 3,580,273,972 gallons a year entering the artesian water beds. An even greater area of the porous beds is covered by later formations than is exposed at the surface. While percolation is much more rapid over the exposed parts, it probably takes place in no small measure through the beds covering the outcrop in other places. It may easily be that the gradual soakage from such overlying beds may be a very important factor in equalizing the supply during long periods of drought.†

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*Pittman. "Problems of the Artesian Water Supply of Australia, etc." Journ. Roy. Soc. N.S. Wales. vol. xli. (1907) pp 100-139. Later figures by Gregory (Geog. Journ. xxxviii. (1911) give these percentages as 6½ and 4 respectively.

The **level** of the intake beds reaches its maximum elevation near Narrabri, where it is about 2250ft. above sea level.

The **outlets, and possible outlets,** of the Artesian Water Basin have formed the subject of a great deal of controversy, and even now it cannot be said that the discussion has reached finality. It seems certain that the principal outlet is towards the Gulf of Carpentaria. Not only does the hydraulic grade fall in that direction but large supplies of water have been observed to issue from the floor of the Gulf even at very considerable distances from land.

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*Since the above estimates were made, an actual geological survey of the intake beds proves their area to be about 10,000 square miles instead of 18,000. The number of cubic feet and gallons quoted must therefore be reduced in the proportion of 18 to 10.—EDITOR.

†The above figures are taken from a paper by Mr. Pittman and Professor David on "Irrigation Geologically Considered with Special Reference to the Artesian Area of N.S. Wales." Proc. Roy. Soc. N.S.W., vol. xxxvii., 1903.

Another possible direction of outlet is towards the Great Australian Bight under Lake Eyre and the Nullarbor Plain. In the Bight streams of fresh water have been recorded as rising through the denser salt water from the sea bottom. It is extremely doubtful if this water belongs to the Great Artesian Basin. It almost certainly has a more local derivation from the the limestones of the Nullarbor Plains.

A third possible direction is through the fairly narrow gap in the older rocks extending from Warwick to Ipswich, in Queensland, close to Brisbane, and thence to the east coast. Still a fourth suggested direction is below the limestones and associated rocks of the Lower Murray to the Coorong coast of South Australia. It is practically certain, however, that the artesian and sub-artesian waters encountered in this region belong to a local basin.

Besides all these possible outlets to the sea, the Artesian Basin possesses a large number of important **outlets on the land surface**. Wherever the outcrop of the water-bearing stratum is below the hydraulic grade, there will the water emerge in the form of a spring. Such springs form a more or less continuous zone marking the limits of the Artesian Basin in the more low-lying portions of its area. The waters always contain a considerable amount of mineral matter in solution, and this is deposited in a more or less conical mound round the orifice of the spring—hence the name "**Mound Springs**" or "**Mud Springs**" applied to these natural outlets of the Artesian Basin. Thousands of such Mound Springs, active and extinct, are scattered about in the central portions of the continent, some of them, particularly some of the extinct ones, forming quite considerable ranges of hills in contrast with the flat country around them.

The **temperature** of the artesian wells calls for some comment. In every case the temperature of the bore water is notably higher than that of the surface water at the place, and in many instances the bore water is extremely hot. It is well known that the temperature of the rocks of the earth's crust increases at the rate of about 1° Fahr. for every 50 or 60 feet of descent. (The increment is rather variable, but the above may be taken as a fair average.) In the case of the artesian basin in Australia the rate of increase is abnormally high. Forty-eight bores in New South Wales give an average of 1° Fahr. for every 44ft. of descent. As the porous bed is in many cases very deeply buried, it must exist under conditions of fairly high temperature, which will also affect the water contained in the bed. While this cause will explain the high temperatures in *deep* wells it fails *per se* to account for the observed distribution of bore temperatures. For this reason, among others, Professor Gregory has been led to challenge the whole theory of the origin of artesian water in Australia.

It is well known that volcanic eruptions, particularly those of great intensity, are always accompanied by the evolution of vast quantities of steam originally dissolved in the molten rock material. The molten rock material is derived from great depths within the earth's crust, where it probably exists in the form of great masses of potentially liquid **magma**, as it is called. Only those masses of magma which actually reach the earth's surface give rise to volcanic phenomena; but other, probably far more extensive, masses are injected into the solid rocks of the outer crust of the earth in the form of **plutonic intrusions**. In such positions the magma cools and solidifies, and, in doing so, parts with its water. According to Gregory this is the preponderant, if not the sole, source of supply of the artesian water in Australia. The derivation of the water from local heated masses of magma may possibly account for certain of the most marked abnormalities of bore temperature. It may also help to explain certain, otherwise unintelligible, variations in the chemical composition of the bore waters, and there can be no doubt that the suggested source of water from plutonic magmas may add to the supply. This view does not necessarily weaken the older theory of origin of the artesian supplies from surface water.

Another possible source of heat must not be lost sight of. Following upon the uplift which usually succeeds long periods of accumulations of sediment, there is always a considerable amount of **folding of the rocks.** In this process heat is generated; and, since the folding follows certain definite lines of weakness, the resultant heat effect is more or less local in character. The presence of islands in the lake or sea in which the porous beds accumulated probably caused a local increase in the coarseness of the sediment, and hence a rapid flow of the artesian water flowing through it. Further, the water tapped on the flanks of such an island probably comes from a much greater depth than the bottom of the bore (Fig. 66), hence its temperature may appear abnormally high.

It is impossible to predict the presence of such islands, and there is always the possibility of a new bore being unfortunate enough to strike the summit of one covered immediately by the impervious beds. In such a case the bore passes directly from the impervious sediments to the impervious basement rocks and the bore is a failure, *e.g.*, Cattle Yards Bore, Bourke. (Fig. 66).

Another cause for abnormally high temperatures is the presence of lines of fracture in the upper impervious beds. A bore striking such a local "leak" may derive its waters from a great ultimate depth. (Fig. 66.)

Differences in conductivity of the rocks forming different parts of the basin may be a contributing cause to the observed differences in rate of increase of temperature with depth.

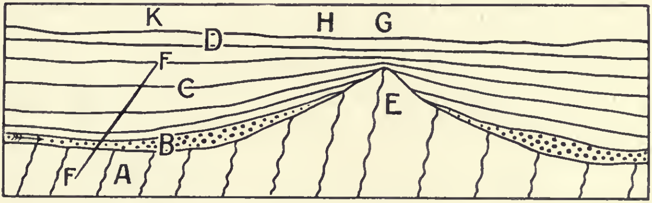

Fig. 66. Diagram illustrating possible causes of temperature anomalies in artesian bores; and one cause of failure of a bore.

Composition of Bore Water.

All natural water is more or less impure. Even rain water contains dissolved impurities, while water that has flowed over or through the rocks is considerably more contaminated as a rule. The solvent action of water upon mineral matter is generally much increased by rise of temperature or pressure, and both of these factors are notably active in the case of bore water.

Length of time of action is another factor to be considered; if water lies long in contact with slowly soluble matter, it gradually becomes a more and more saturated solution, and this is one of the most important arguments against a closed artesian basin, since our bore waters are not very saline as a rule.

Taking the above factors into consideration, we should expect the following rules to hold with respect to the composition of bore water, namely:—

(1) The greater the distance of a bore from the intake the more saline it should be.

(2) The deeper the bore the more saline it should be.

The problem is, however, by no means so simple as this. As shown under the heading of temperature variations, many complications arise through uncertainty as to the depth from which some of the water has been derived, and from other causes. There does seem to be a progressive increase in salinity as we pass from the intake (remembering that the chief intake is in eastern Queensland). The average salinity* of 143 samples of bore water from Queensland is 47.94 grains per gallon, of 177 samples from New South Wales 56.35 grains per gallon, and of 14 samples from South Australia 141.62 grains per gallon. While these averages conform to the general laws above enumerated, those of individual bores show most irregular variations. In bore sinking it is the rule rather than the exception to find that water is struck not in a single band of porous rock, but in several such bands lying at different depths. The upper water-bearing bands almost invariably yield much less abundant and more saline water than the stratum which lies immediately upon the basement rocks. One reason which probably accounts for both of these facts is that these upper bands are finer in grain than the lower, and hence less porous. The amount of water contained, and its rate of flow are decreased in this way, hence the yield is small; also the slow rate of flow permits much more solvent action than is the case with the more rapidly circulating water in the bottom stratum.

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*Pittman, E. F., op. cit

Table of composition of Bore Waters.* Quantities are stated in grains per Imperial gallon.

Bore.	District.	Sodium Carbonate.	Potassium Carbonate.	Calcium Carbonate.	Sodium Chloride.	Total Solid Matter.
Coonamble No. 2	Coonamble	7·189	3·739	11·742	2·305	30·662
Pera No. 2 ...	Bourke	35·107	trace	1·300	12·140	50·220
Clifton	Wanaaring	98·180	1·641	1·699	21·480	125·830
Cuttaburra ...	,,	6·712	...	6·664	349·040	396·872
Tundebarine No. 3	Coonamble	1·461	1·571	3·300	2·412	13·605

From the above table it will be seen that **sodium carbonate** (washing soda) is generally the most important dissolved solid, with **sodium chloride** (common salt) next. The other constituents are in minor proportion only, as a rule.†

Uses of Bore Water.—There is a good deal of misconception rife as to the use of bore water. The popular opinion is that its prime importance is for **irrigation**, which is far from being the case. The composition of the water does not make it specially suitable to this use. Sodium carbonate is a powerful alkali, and has a most injurious effect upon the root fibres of plants; and, moreover, tends to accumulate in the soil as a result of evaporation. After the first application of bore water to the land, phenomenal crops are obtained from the virgin soil, but after a time the deleterious effect of the alkali makes itself felt. Even with waters of the same composition considerable differences in effect are noticed in different cases. The more porous red soils respond less quickly to the harmful action than do the more sticky black ones, and suitable methods of application of the water and of subsoil drainage mitigate the evil to some extent. Surface-feeding crops, such as citrus fruits, may thrive for many years, possibly indefinitely; while those which send down deep tap-roots are quickly affected. Some crops, *e.g.*, lucerne, require frequent waterings, and with them more alkali is introduced into the soil than with other crops, like cereals, which require much less frequent waterings.

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*Particulars of Bores in N.S. Wales. June, 1910.

†Recent analyses have shown that waters from the lowest porous strata are relatively rich in potassium carbonate and poor in sodium carbonate; in waters from the upper porous beds the reverse is the case. Potassium carbonate is a good food for plants.

Various attempts have been made to overcome this difficulty. The action of gypsum (calcium sulphate) tends to convert the soda into sodium sulphate (Glauber's salt) with calcium carbonate (chalk) as a bye-product. The salt in this case is much less injurious than in the former. The conversion has not been sufficiently complete to remove the harmful qualities of the water.

Neutralization with nitric acid has been tried with complete success on an experimental scale. This reaction forms nitrate of sodium. This is an excellent plant food, and vast quantities of it are imported from Chili to form artificial manures. Unfortunately the cost of the nitric acid necessary is far in excess of the profit obtained from the crops produced, so that, at present, the process is not economically successful. The suggestion to use the power of the water pressure in the bore itself to manufacture nitric acid electrically from the air involves the closing down of the bore orifice to such an extent that a serious diminution of supply may be anticipated.

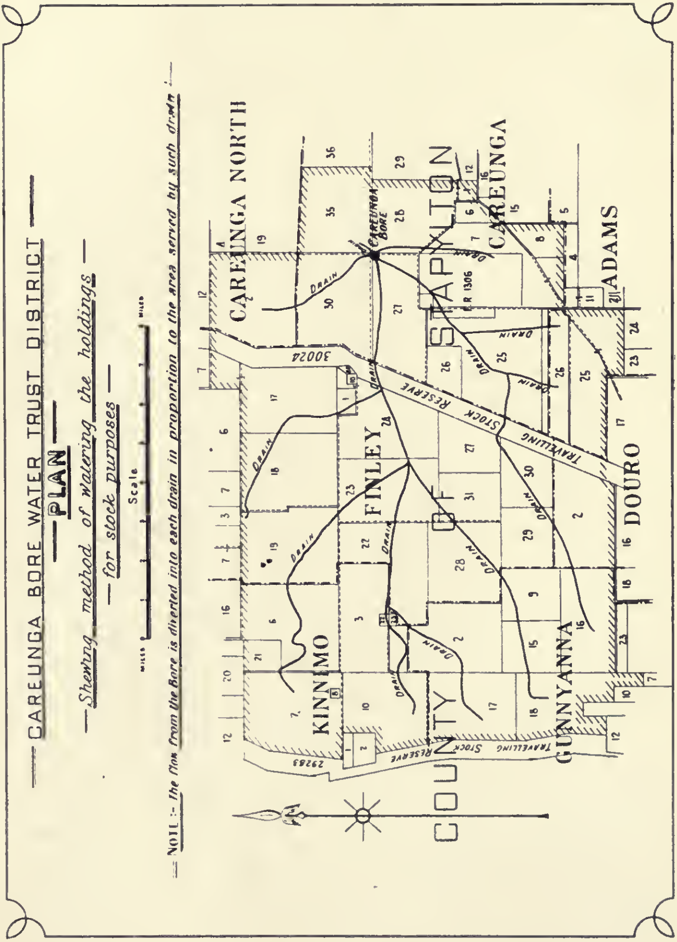
CAREUNGA BORE WATER TRUST DISTRICT
PLAN
Shewing method of watering the holdings
for stock purposes
Scale
MILES
NOTE:- The flow from the Bore is diverted into each drain in proportion to the area served by such drain.
CAREUNGA NORTH
CAREUNGA
CAREUNGA BORE
STAPYLTON
ADAMS
DOURO
FINLEY
KINNIMO
GUNNYANNA
COUNTY OF STAPYLTON
DRAIN
TRAVELLING STOCK RESERVE
30024
29283
R 1306

Fig. 67. Water Trust Drains.

It may be pointed out, too, that the soils in the Artesian Belt are already somewhat too nitrogenous, and to further increase this element in the plant food would induce too great a leaf growth.

Finally, the water is not sufficiently abundant for irrigation on a large scale, as will presently be shown.

Undoubtedly the chief value of the water is for **stock purposes.** (Fig. 67.) The climate and other conditions in the western plains are ideal for sheep-raising, provided grass and water can be assured. Except, during occasional droughts, the normal rainfall provides for the former. On such level areas, however, water conservation by means of tanks and dams is difficult and expensive, and, moreover, is likely to fail just when most needed, in time of drought. The gentle fall of the country, about 18 inches in a mile, makes it extremely easy to distribute water obtained from an artesian bore, by means of simple drains. In this way stock watering can be carried out over enormous areas. A fair estimate is that, on an average, a bore yielding 1,000,000 gallons a day can distribute water for stock purposes over an area of 100,000 acres of land in such a way that stock need never walk more than a mile for water. The same amount of water will irrigate, for intense culture, only about 500 acres. In opening and maintaining stock routes along which flocks may travel to market in ordinary seasons, and to areas where food is obtainable in time of drought, the bores provide one of the most important means of mitigating the effects of drought.

The use of the water pressure to drive shearing machinery, electric light, and so on, is extremely limited as it involves considerable diminution in the flow.

In a few instances the bores, permanently or intermittently, **provide water supply for important towns** like Bourke, Coonamble, and Moree.

Chapter XIII.—THE CAVES OF NEW SOUTH WALES.

(T. G. Taylor, B.A., B.E., B.Sc.)

Possibly the geographical feature in the State of New South Wales which has attained the most world-wide reputation is the cluster of caves situated at **Jenolan.** No physiographical account would be complete without some reference to this marvellous locality, and to other equally wonderful but less well-known caves in other parts of the State.

A glance at the sketch map (Fig. 68) will demonstrate several facts. In the first place the caves all occur in the **central portion** of the State, which constitutes also the oldest portion geologically speaking. No caves are found in the western plains, nor in the Great Coal Basin. The belt of ancient sediments extending from Wellington to Kosciusko is, however, relatively speaking riddled with these huge cavities. Secondly, if the areas of limestone in which the caves invariably occur, are mapped fairly accurately, they are seen to be, in general, **oval** in shape with the long axis extending north and south. Often after a break of ten or twenty miles a similar "limestone oval" is reached, and sometimes a chain of these occurs along one direction. Thirdly, the limestone is almost always very hard, compact, and of a dark bluish colour when freshly broken. Moreover, it usually contains **fossil**

marine shells and fossil corals, which, though very different from those living nowadays, are yet related to them. Hence we may fairly assume that the limestone was in process of formation when the former

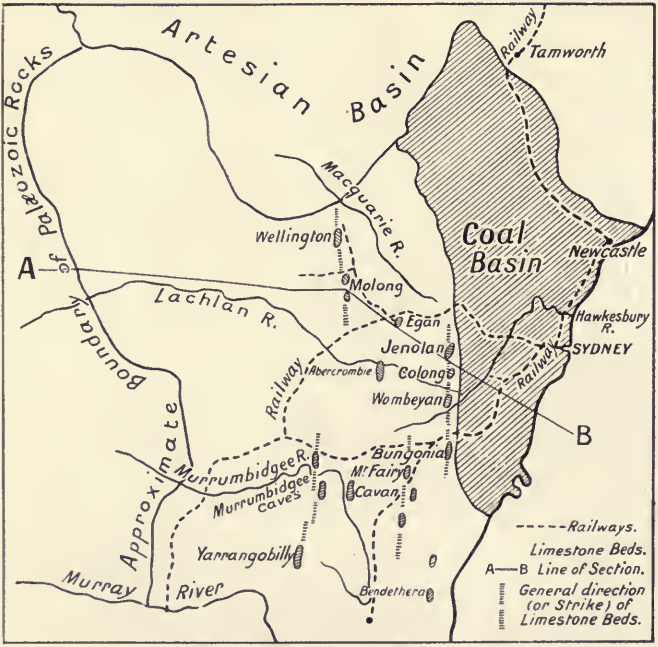

Fig. 68a. Sketch Map of Caves area.

organisms were alive, and thus we can picture the process which has led to the building up of these huge deposits.

We may ask whether there are any huge deposits of limestone forming at the present day? Have these deposits if there be such, any points of resemblance to the limestones of Jenolan, Wombeyan, etc.?

To the first question one can answer that a huge belt 1200 miles long and 30 to 100 miles wide, has gradually accumulated off the Queensland coast in the shape of the **Great Barrier Reef**. As we shall see, they have quite enough characteristics in common to justify us in supposing a similar origin for the two, although separated in age by millions of years.

A castellated rampart (each projection being a reef) rather than a gigantic unbroken wall, fitly describes the structure of the **Barrier reefs**. On the surface of each reef appears a layer of coral sand filling in the cavities of dead and broken coral. The living coral forms only a narrow fringe some 100 to 300 feet wide around each reef, and is torn off in lumps by every gale and thrown on to the reef. Gradually the reef becomes more and more solid as the fragments and coral sand become cemented together. If the land is neither rising nor sinking slowly, the coral reefs gradually build out to leeward and become almost solid lumps of coral limestone with only a fringe of living coral all round. If the land is sinking, possibly more of the organic material, coral, shells, etc., remain distinguishable though covered by succeeding layers of coral *débris* and coral sand. If the land is rising, and of course carrying the reef up also, then the limestone belt does not attain the bulk of the preceding cases.

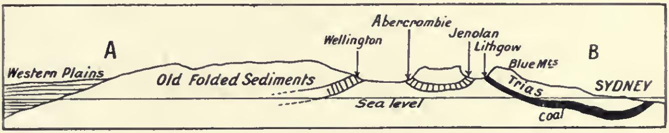

Fig. 68b. Section across Caves Area.

One may imagine that after long geological periods, the earth experiences some climatological change leading to the destruction of coral life. Thus we have evidence of **glaciers in past ages** in Queensland (Bowen River). Or the dead corals may be buried under river silt and marine sediments, and squeezed by earth folding into a much more compact limestone than the somewhat porous whitish material known as **coral-rock.**

Ensuing changes in this far-distant period again expose our limestone as a land-surface rock to the action of rain, river, and wind, and then begins the formation of a series of Great Caves.

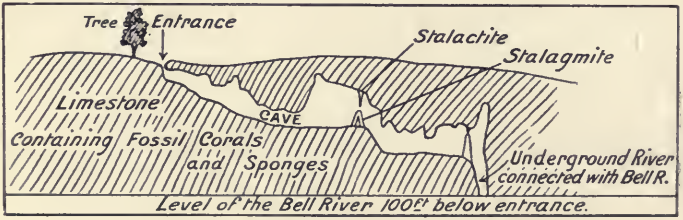

Fig. 68c. Section through Wellington Caves.

Limestone is known in chemical language as an impure **calcium carbonate** or **carbonate of lime.** This material is insoluble in pure water, but is soluble in water containing a certain amount of a weak acid known as **carbonic acid.** This carbonic acid is produced when carbon dioxide is dissolved in water. Now carbon dioxide is a gas under ordinary conditions of atmospheric temperature and pressure, the same gas that is evolved from effervescing drinks such as soda-water. Whence comes the carbon dioxide necessary to dissolve the limestone? A certain percentage is always present in the air, derived largely from the oxidation of carbon in animal respiration; but more important for our purpose is the very large amount derived from subterranean sources, possibly on the disintegration of rocks like granite, which include an appreciable quantity of liquid carbon dioxide in small cavities, and from many underground springs. One well-known spring near Cooma, yields a natural effervescent soda-water, which indeed owes its economic value to the amount of gas contained in the water.

Having explained the origin of the belt of limestone, and of the water containing the carbonic acid which forms the active solvent of such rock, it remains to discuss the method of erosion and the form of the resulting structures.

All rocks, even granite and the hardest sandstones, are to a certain extent cracked and displaced, "jointed and faulted." The acidified water, whether as rain water or spring water, attacks the outcrop of limestone and soon discovers these cracks. Here it finds what engineers term a "free face," and is able to dissolve off the limestone much more rapidly than at more solid portions of the rock. Finally it may excavate, by combined wearing away and solution, an underground tunnel extending in a zig-zag and highly irregular manner from crack to crack; or, as has been stated, "now plunging downward at high angles, or even vertically, through relatively constricted clefts and fissures; now winding through approximately horizontal tunnels or forming lake-like expansions in broad lofty halls and chambers; now dividing into numerous torrents and streams, which zig-zag downwards to lower and lower levels."*

But the caves would be barren hollows devoid of beauty were there not a **process of construction** working at the same time as the process of solution.

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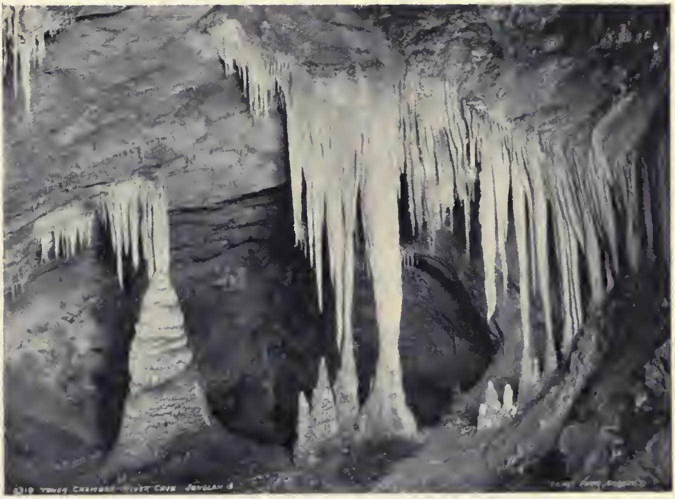
*Earth Sculpture, Geikie p. 215

The acid water containing the lime carbonate in solution may, under favourable circumstances, evaporate, and then the limestone is deposited as a white solid material. Thus, when a supply of such lime-bearing water percolates along a crack and issues at the roof of a cavern, it remains hanging on the roof as a drop for an appreciable time. Some water evaporates, and though most of it drops finally, yet a thin layer, or pellicle, of lime carbonate is left after each drop. After it may be hundreds of years, a calcareous rod is formed, and this is called a **stalactite**. Similarly the evaporation of the drop as it splashes on the floor leads to the building of a more bulky pillar on the floor, a **stalagmite**, which will eventually grow to meet its roof-mate, and form one complete column. Examples of such union are common in all our caves, while the fantastic shapes assumed by the stalactites are known to all. (Fig. 69.)

Many of the caves may have formed the dens of the Tasmanian wolf, a carnivorous marsupial. Under a thin layer of stalagmite, which has effectually preserved them, there appears a cemented mass of bone fragments derived from animals long since vanished from the earth. For instance, at Wellington were found bones of the huge 16-foot Wombat,—**Diprotodon**, and of various extinct emus and native bears.

Finally a word as to the distribution of these cave limestones. They occur with deposits of the Palæozoic age, which contain fossils similar to those known as Silurian or Devonian in England, and have, therefore, been referred to that period of geological time. Possibly during Silurian or Devonian times the

Australian seas largely resembled the dangerous waters of Torres Strait, being full of masses of coral growth. After being buried under many thousand feet of later sediments, and folded from east and west so as to throw the limestone beds into a series of ridges and furrows running north and south, they again constituted a land surface.



Kerry & Co., Sydney.

Fig. 69. Stalactites and Stalagmites Tower Chamber, River Cave. Jenolan.

These oval limestone areas may, therefore, be described in general terms as the **exposed outcrops of a series of fossil coral reefs**, which (originally level) have been folded into a complex series of troughs and ridges, the main axes running north and south.

Chapter XIV.—CLIMATE OF NEW SOUTH WALES.

(T. G. Taylor, B.A., B.E., B.Sc.)

Introduction.—The earth on which we live is surrounded by a gaseous layer, or shell, of air known as the atmosphere. This atmosphere consists chiefly of a mixture of two gases, **Oxygen** and **Nitrogen**, together with small but important proportions of **Argon**, **Water-vapour**, and **Carbon-dioxide**. The composition by volume is as follows:—

Nitrogen	78.1
Oxygen	20.8
Argon	1.0
Water-vapour	variable
Carbon-dioxide	0.04

With regard to these gases, it is sufficient to state that oxygen is the vital principle in the air we breathe, being absorbed by, and revivifying the blood: nitrogen serves chiefly as a diluent, as also does argon, which is even more inert than nitrogen. The presence of the variable amount of water-vapour and carbon dioxide is important, as we shall see, in connection with the "blanketing effect" which these gases produce on the lithosphere, or solid part of the earth below. The rainfall is also directly dependent on the water-vapour present, while many of Nature's chemical processes depend on the solvent action of a solution of carbon dioxide ("carbonic acid gas" as it was formerly called) in water.

We may picture the atmosphere as a mass of infinitely small gaseous particles, or **molecules**, of several kinds as just noted, mingled together in fairly definite proportions. These molecules, though of microscopic size, one thousand million or so extending over a linear inch, have a definite weight. It can be readily understood that the lower layers of air will be packed somewhat closer together than those at a higher elevation, thus increasing its density; while towards the upper limit of the atmosphere the molecules are farther apart, with the result that the air there is "rarer."

There is, however, no well-defined limit to the upper extent of the atmosphere. The friction between falling meteorites—which consist commonly of a mixture of stony material and nickel-iron—and the air particles, causes the former to become heated to the glowing point. This glowing seems to take place about forty miles above the lithosphere, and tells us that at that distance the atmosphere is appreciably present. However, if the molecules were spread in an even layer all round the earth so as to form a mass of the same density as generally prevails at the surface of the earth, it has been calculated that this layer would be about five miles thick. For purposes of calculation of the weight and pressure of the atmosphere we may use this idea of an **atmosphere of uniform density about five miles thick.**

Weight of the Atmosphere.—The French chemist, Regnault, found that one litre (about 1¾ pints) of pure and dry air at normal pressure and temperature weighed 1.29 grams, say 20 grains. If we consider the vast thickness of the atmosphere we can readily understand that its total weight must reach an enormous figure. As a matter of fact, each square inch of surface about sea level has to bear a load of 15lbs. An air-tight structure subject to this pressure can, therefore, only retain its shape through the rigidity of the material of which it is composed, or because there is some opposing internal pressure. If the air be removed from within an indiarubber bladder, the walls of which have practically no rigidity, the pressure of the external air squeezes the walls together.

Let us imagine four columns, each of one square inch in cross section. The first a column of **air** of uniform density, second a similar column of **water vapour**, third of **water**, and fourth of **mercury**. Suppose the air column to be **five miles** high, it would weigh about 15lbs. The water vapour column would reach **eight miles** to be of equal weight under similar conditions. The water column would be **32 feet** high, and the mercury column only **30 inches.**

Effect of Temperature on the Atmosphere.—When the atmosphere is heated it expands. If we return to the concept that the air is a collection of gaseous molecules, it may be taken for granted that if an increase in temperature takes place, the molecules move further apart. Hence if there were one thousand molecules enclosed in a bladder and the temperature were increased the molecules would move away from each other, and the bladder would necessarily expand. There would now be less than one thousand molecules in the original space occupied by the bladder. On cooling to the original temperature, however, the molecules would move together and the air would occupy the same space again as at the start of the experiment. Thus a pint of cold air obtained from the North Pole would be heavier—other things being equal—than a pint of warm air from the Equator, since in the latter case there would be fewer molecules present.

When a liquid such as water is heated, it changes its state and becomes water vapour, or steam. Essentially this means that the water molecules are driven farther apart from each other. So that the heat must be applied to the water not only **to raise its temperature** to the requisite degree, but also to perform **the work necessary in separating the molecules.** The latter portion of the heat absorbed by the water does not make itself apparent, since a thermometer placed in boiling water remains at 100° C. until all the water is transformed into vapour—and is hence known as *Latent Heat* (latent = hidden). The converse operation is equally true. When water vapour is condensed to water, a very considerable amount of heat is set free, equal to that amount rendered latent in the preceding operation. This phenomenon—the realisation of heat on condensation—is of great importance in connection with questions concerning rainfall and the theory of tornadoes.

Another matter of great importance is the "blanketing effect" of the atmosphere. It is well known that the temperature decreases about 1° Centigrade for every 540 feet of ascent (or 1° Fahrenheit for 300 feet) into the upper zones of the atmosphere. Pure air allows the passage of heat rays without depriving them of any appreciable amount of heat. It is "diathermous" in fact. But **moist** air absorbs large quantities of the heat which passes from the sun towards the earth, and also very largely prevents the loss by radiation of that which has already heated the crust of the earth. The sun's rays falling on a mountain of only 7000 feet elevation, *e.g.*, Kosciusko, have a very strong blistering action, owing to the thin nature of the "air blanket," whose increased thickness in the lower zones filters out much of the fierceness of those rays.

Pressure of the Atmosphere.—The instrument of prime importance in Meteorology is the *Barometer.*

This is an apparatus for measuring the pressure of the atmosphere; and the principles underlying its construction must be thoroughly understood before we can appreciate the results obtained by its use. It has already been shown that a column of mercury 30 inches high will balance the weight of five miles of an air column of equal cross section, where this latter represents the whole thickness of the atmosphere accumulated into a layer of uniform density.

If a glass tumbler be filled with water and a piece of writing paper be placed over the mouth, the glass may be inverted without escape of the water. Here the surface of the liquid is kept entire and the pressure of the atmosphere, which acts equally in all directions at the same level, exceeds the weight of the water, and so the latter remains in the glass. This simple experiment helps us to understand the barometer.

The ordinary mercuric Barometer consists of a vertical glass tube about 33 inches in length closed at the upper end, with the lower end dipping into mercury.

The mercury column represents exactly the pressure of the air above the level of the mercury in the basin.

Suppose that the air becomes lighter about the instrument, obviously the mercury column will become shorter, *i.e.*, lighter, in consequence. So that when the barometer "falls" we know that the air has become lighter, and when it "rises" we know that the atmospheric pressure is increased.

There are many hundred stations in New South Wales where barometer readings are noted every day. The figures (30 inches, etc.,) are sent to a central office, and are plotted on a map of the State; then lines are drawn connecting all stations showing the same reading. These lines of equal barometric pressure are called **isobars**; and by means of the curves thus obtained the Meteorologist is able to state the probable direction and effect of future air currents.

Another physical fact of importance in this connection is the behaviour of gases when compressed, or subjected to diminished pressure. **When air is compressed it becomes heated.** A familiar example is the action of pumping up a bicycle tyre; there is a great tendency, especially if the tube be of small bore, for the end of the pump to become quite warm. The converse is equally true, that **when air expands it cools.** Hence when air ascends and reaches regions of lower pressure, it expands and is cooled; apart from the fact that the upper regions are themselves cooler through the tenuity of the "blanket" of water vapour, etc. We shall see the importance of this when considering the relation between mountains and rainfall.

General Circulation of the Air.

Ideal Circulation on a Sphere.—When air is heated it expands, and a given bulk becomes lighter in consequence. Such air when surrounded by cooler air must rise and we have a circulation set up, since the surrounding cold air, being heavier, presses in below and displaces the warmed air. This is the way, in fact, that many coal mines are ventilated. A furnace at the foot of one shaft heats the air in that shaft reducing its pressure so that it no longer balances the cool air in a second or "downcast" shaft, the current thus set up passes through the various workings of the mine on its way to the "upcast" or furnace shaft.

Let us imagine the condition of affairs on a sphere of the same size as the earth, but **stationary in space,** and without the irregular distribution of land and sea which now exists. The sun's heat would warm the air at the equator giving rise to an ascending current of air. The colder dense air in higher latitudes, north and south of the equator, would flow in below, giving rise to a wind along the surface of the earth towards the equator from the north, in the northern hemisphere, and from the south, in the southern hemisphere. There would thus arise a bulge in the atmosphere over the equator, producing an overhead stream of air (anti-trade wind) flowing polewards. This latter stream would tend to descend about latitude 40°, chiefly because the air is becoming chilled and therefore heavier. Moreover the area available for its passage is diminishing as it approaches the pole, and therefore the air would tend to pile up about this latitude. It is thus evident that we should have an area of warm **light** air at the equator giving a **Low** pressure belt; and on each side a belt of **High** pressure about latitude 35° or 40° where there is an accumulation of dense cold air.

A belt of **Low** pressure coinciding practically with the Antarctic circle, and due possibly in part to the large amount of water vapour in those latitudes, and finally a gradual increase in atmospheric pressure towards the intensely cold **High** pressure region of the South pole—as shown by the prevalent north-blowing winds of Antarctica—sums up our knowledge of Antarctic Meteorology.

Actual Circulation of the Air.—The foregoing conditions are, however, greatly modified on the actual World Sphere by two factors. Firstly the **diurnal rotation** from west to east, which gives the equator a speed of roughly 1000 miles per hour while the poles are relatively stationary, and, secondly the **irregular distribution of land and sea.**

Effect of Rotation :–

The rapid movement of the equator combined with the pole-seeking direction of the wind, gives rise to a steady wind in the upper regions of the air, which is known as the **Anti-Trade Wind.** In the southern hemisphere it flows from the north-west to the south-east. The return current which flows along the surface blows for a similar reason from the south-east to the north-west. This is known as the **Trade Wind,** and blows very regularly over the great ocean expanse between the sub-tropics and the Equator.

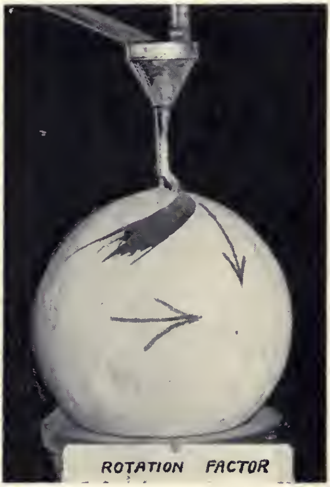


Fig. 70. Rotation Model.

The model represented in Fig. 70 clearly illustrates the origin of the trade winds. A ball surmounted by a funnel is rotated about a vertical axis. Pitch delivered from the funnel on to the ball a little way from the axis would flow down the surface of the motionless ball in the direction shown by the vertical arrow; but if the ball is kept rotating in the direction of the horizontal arrow, the pitch is seen to take the direction shown by the broad black streak.* Hence the direction of the North-east Trade. The **South-east Trades** can be explained in a similar way; but it is not so easy to carry out the experiment for the Southern Hemisphere.

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*This model was made by Professor David, F.R.S.

The Anti-trade blowing from the equator in a south-east direction towards the South Pole, becomes deflected more and more towards the east as it gets further from the equator. We may imagine, therefore, a broad elevated belt of air travelling from west to east along the latitude 30°. Its path is fairly free from obstructions with the exception of the Andes, and perhaps the Drakensberg of South Africa and Australian Alps. Figs. 71 A and B.

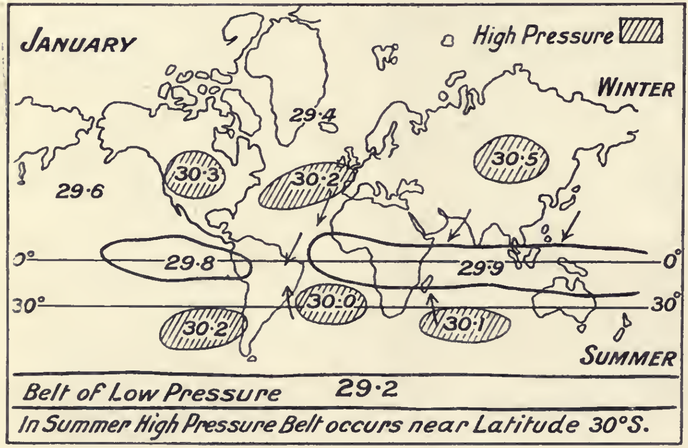

Fig. 71a. Pressure Zones.
In southern summer the high pressure belt occurs near latitude 30° S.

Further to the south, in latitude 40°, there occurs the most open belt on the earth's surface; and here the deflected anti-trade, which has sunk down to sea level, has a clear path and is known as the "**Roaring Forties,**" the name having reference to the latitude traversed.

South of the Roaring Forties is the **Low** pressure belt already alluded to, which has been accounted for "by assuming it to represent the inner edge of a ring of westerlies (Roaring Forties) whirling about the

South Pole. The centrifugal force thus set up tends to increase the pressure on the outer edge, about latitude 40°, and gives rise to a low pressure belt on the inner or polar edge, some 20° farther south."

Effect of Land Distribution.—A reference to the charts of the world showing barometric heights for summer and winter demonstrates the enormous influence of the great land masses. The **Antarctic belt of low pressure** extends uniformly around the world since no continents disturb the surface of that belt of water called the Southern Ocean.

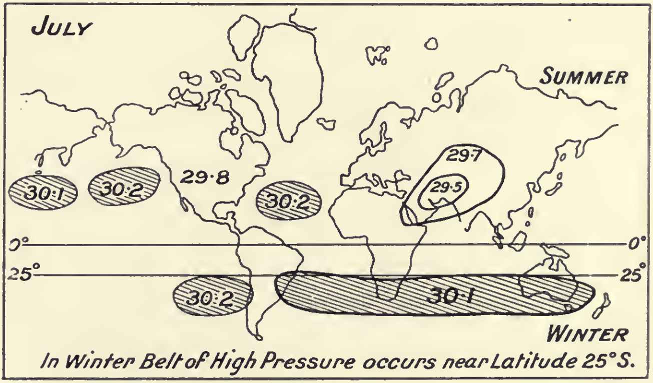

Fig. 71b. Pressure Zones.
In southern winter the belt of high pressure occurs near latitude 25° S.

No corresponding belt is present in the Arctic regions. The **belt of high pressure** in the Southern Hemisphere, though not continuous, is a much more stable phenomenon than in the Northern Hemisphere for a similar reason. Indeed, the pressure of the atmosphere, and therefore the climate and rainfall of the Eurasian land mass, is largely controlled by the presence of the immensely elevated mountains and plateaux of Tibet. There is no disturbing influence like this in the Southern Hemisphere.

In summer (July) in the Northern Hemisphere, all the isobars of Asia, those of Eastern Europe and Africa, and even of Northern Australia circle round the **intensely heated areas** between the Persian Gulf and Tibet. Here the air is always rising during the summer, causing an inflow, known as the Summer Monsoon, from surrounding regions towards the area of low pressure. (LOW).

If the same amount of solar heat falls upon equal areas of land and water it raises the temperature of the land more than four times as much as that of the water. On the other hand the heat is dissipated very much more quickly by the land surface than by the sea. The above statement explains two important classes of winds, the **Seasonal Monsoons**, and the **Daily Monsoons** (or Land and Sea Breezes). The latter class, as being of somewhat simpler type, may be first considered.

Along the New South Wales coast the conditions are rather favourable in this respect. Elevated land masses are situated close to a large ocean along the major portion of the shore line. During summer especially, the contrast between the waters of the Pacific, which have a fairly uniform temperature of 70° F., and the strongly-heated rocky slopes of the Great Divide and its spurs, sometimes subjected to a temperature of over 100° F., leads to an inflow of cooler air from the sea. This daily current is known as the **sea-breeze**. and usually attains a maximum about 3 or 4 p.m., dying away as the sun sets when the rocks rapidly lose their heat. During the night the conditions are generally reversed, so that the land temperature sinks below that of the ocean waters, and consequently a land breeze springs up.

This somewhat simple type of circulation is, however, more usually masked by more powerful air currents due to other influences, to be discussed later, such as **Anti-cyclone** whirls. Its importance is therefore secondary according as the **local** factor, *i.e.*, the daily monsoon, helps or hinders the course of the dominant factor, *i.e.*, the Anti-cyclone, which often influences the **whole** State at one time.

Any given wind is generally due to a combination of several factors, some, however, exerting more influence than others.

WINDS OF NEW SOUTH WALES.

Perhaps the chief units in the broad distribution of land and sea which affect the climate of Eastern Australia are the following:—

a. The low lying centre of Australia.

b. The huge land mass culminating in the Himalayas.

c. The barrier which the Andes opposes to what is otherwise

d. The fairly open belt of the Southern Ocean.

The Seasonal Monsoons.—The low elevation of Australia causes the Asiatic Monsoon to exert much more influence on our climate than would otherwise be the case. During the northern summer (July, etc.) the air currents from North-east Australia are directed towards the Asiatic LOW, and thus reinforce the south-east Trade Wind. A very strong and constant South-east Wind due to these conditions is the prevalent wind in **winter** along the Queensland Coast, and to a certain extent further south. As will be seen later, this Asiatic Monsoon is not of such importance in New South Wales as in Northern Australia, at any rate in winter, the weather conditions in New South Wales depending then on a different set of factors, *i.e.*, the Anti-cyclones.

In **summer** there is a region of low pressure in Central Australia due to the high temperature of that area. This results from the southern position of the sun which approaches the Tropic of Capricorn. The atmospheric belts of high and low pressure swing north and south in unison with the motion of the sun, so that during our summer we are more under the influence of the equatorial low pressure belt than at other times of the year.

In the northern winter, the heavy air, chilled by the Himalayan land mass, is flowing away from the latter. In North Australian regions we get as a result a fairly constant wind produced by a combination of the winter monsoon (bringing dense air from the Himalayas) and the Trade wind of the Northern Hemisphere. These air currents blow towards the heated centre of Australia.

The dominant feature in the Meteorology of our State is the passage from west to east of the great **anti-cyclone areas.** It will be remembered that the great anti-trade current gradually sinks as it progresses towards the poles, and about the latitude of Sydney it probably flows towards the east, some 10,000 feet above sea level. Thus a balloon which ascended over Ashfield during a *sea-breeze from the east,* was blown *to the east* by the anti-trade at an elevation of several thousand feet, and descended at George's River. Further to the south, at a somewhat lower elevation, the Observatory hut at Kosciusko

(7000ft.) lies in this belt of westerly winds. We may compare this enormous air-flow to a river with a fairly unimpeded course for the most part, but with several steep ridges across its bed, corresponding to the obstruction offered the eastward flow of the atmosphere by the Andes, Drakensberg, etc. In the river under such circumstances a series of eddies would undoubtedly be formed in the lower portions of the current, which would be fairly stable systems and be swept along for a considerable distance before being dissipated.

In the atmosphere there is a similar tendency to form huge whirls or eddies in the lower strata which travel, under the urging influence of the westerly drift overhead, about 400 miles a day. These whirls constitute the **Anti-cyclones**, which may be looked upon as slowly revolving air-columns projecting down from the anti-trades at regular and not distant intervals.

With the seasons this belt of anti-cyclones **moves to north or south** in sympathy with the sun's position. During summer, when the sun advances south to the Tropic of Capricorn, the belt occupies a position whose centre corresponds roughly with the 30th parallel. In winter as the sun moves north over the Equator the belt's centre recedes to 25° south latitude. These anti-cyclones are huge eddies in the high pressure belt. They cover an area, usually oval with the long axis east and west, generally 1500 miles long and about 1000 miles wide, and, as previously stated, their centres travel about 400 miles a day. About forty-six anti-cyclones cross Australia every year.

Let us see how an anti-cyclone is detected. Obviously one cannot observe 1500 miles of country at one glance.

When the **isobars** previously described have been plotted on the map it at once becomes evident that, in the case of an anti-cyclone, they tend to form a series of ellipses surrounding a point of maximum pressure, this point constitutes the centre of an anti-cyclone, and its position on the map is seen to move on from day to day at the rate above mentioned. The highest readings lie in the inner curves, and the barometer falls as one recedes from the centre of the HIGH, as this area of high pressure is technically labelled.

As in the case of water, so in air, the currents move from areas of high to areas of low pressure. With the barometer readings as indicated this gives rise to a set of winds blowing from the centre outwards. The rotation of the earth, however, affects this movement, as in the case of the huge anti-trade current itself (*vide antea*). In that case we saw that a wind towards the poles was **deflected to the left** (from the point of view of an observer with his back to the wind) in the southern hemisphere. This deflection affects practically all moving bodies in some degree or other, and **Ferrel's Law** states that—"All bodies moving in the Southern Hemisphere have a tendency to move to the left, but to the right in the Northern Hemisphere."

In the anti-cyclone area each current of air from the HIGH in the centre has a left-hand component impressed on it. This causes the winds derived from this area of high pressure to blow in a somewhat tangential direction, in the opposite way to the movement of the hands of a clock. Hence, in the Southern Hemisphere the **winds blow around an anti-cyclone area in a counter-clock-wise direction.** (Fig. 72).

Suppose one of these anti-cyclone areas to be approaching Sydney: in front of the central HIGH the winds blow outwards, and, owing to the left-hand deflection, northwards; so that a southerly wind is experienced. If the **centre** of the area moves eastward over Sydney **calm bright weather** will be experienced. In this portion of the anti-cyclone the air currents are, to some extent, blowing downwards to supply the place of that moving outwards in the lower layers. Hence the upper cool air is reaching warmer, surface, regions, and has therefore no tendency to deposit rain or form clouds and mist.

Under normal conditions in a week or so the anti-cyclone will have moved over to the east and winds from the north, proper to the rear of the eddy, will be experienced. Along the northern portions of an anti-cyclone area easterly winds, and in the southern portions westerly ones, are normal in the Southern Hemisphere.

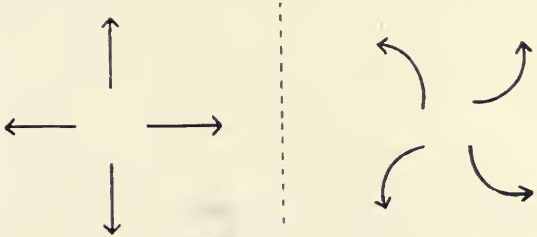

Fig. 72. Anticyclone air-currents.

Second only in importance to the anti-cyclones are the **cyclones**. These are whirls in the lower layers of the atmosphere of a converse nature to the anti-cyclones. They consist of areas of spirally-moving air, in which the pressure decreases gradually as the centre is approached. The air hence has an inward motion flowing spirally in towards the centre and then rising. In the Southern Hemisphere the direction of the winds of the system is **clockwise**. Their mode of origin is not yet clearly understood. In some such way as the anti-cyclones flow eastward near the great belt of high pressure, so these cyclones are whirls fringing the low pressure belts of the Equator and Polar Circles. Thus, as a rule, they chiefly occur in two zones, one on each side of the anti-cyclone belt. Indeed it seems probable that the whirls of the latter zone are to some extent fed by the cyclonic areas; the air in the latter rising at the centre, moving overhead, and flowing down the centre of the high pressure eddies.

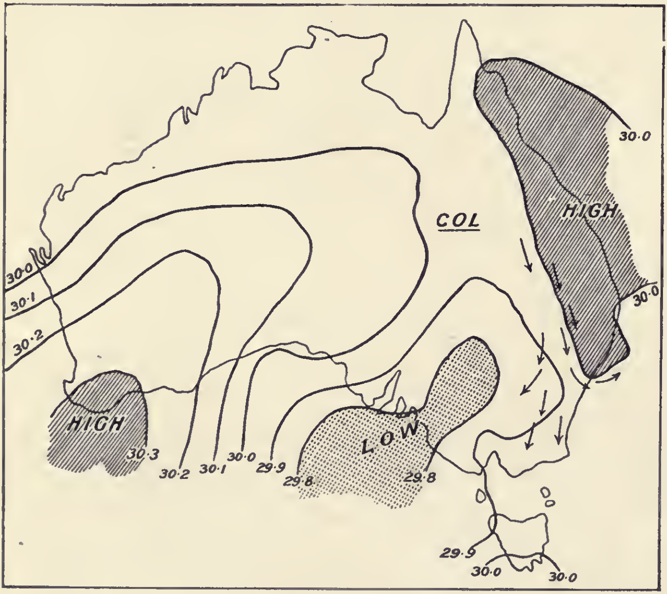

Fig. 73. Australian Isobars.

As will be seen from the examples shown in weather charts, the normal condition in Australia consists of a pair of anti-cyclones alternating with a pair of cyclones, the latter lying one on each side of the **Col**, or intermediate area, between the anti-cyclones. (Fig. 73).

The air in cyclone areas has an upward tendency; the dense surrounding air flowing in to replace the latter air rising at the centre. Thus the centre of a LOW, or cyclone area, is often characterised by cloudy weather due to the cooling of the air in its ascent. Rain and storms are much more usual under cyclone than under anti-cyclone conditions, as will be explained later.

Readers are cautioned against confounding these large, fairly stable, circulatory systems, cyclones or LOWS, with local violent gyratory storms, or **tornadoes,** to which the term cyclone is often wrongfully applied.

The following table indicates the chief characteristics of anti-cyclones and cyclones respectively, with the weather conditions to which they usually give rise:—

TABLE.

Anticyclone:	**Cyclone:**
An atmospheric whirl revolving *counterclockwise* in the Southern Hemisphere, (and *clockwise* in the Northern Hemisphere).	An atmospheric whirl revolving *clockwise* in the Southern Hemisphere (and *counterclockwise* in the Northern Hemisphere).
An area of *High* pressure, hence the winds blow spirally outwards.	An area of *Low* pressure, hence the winds blow spirally *in* to the centre.
In Australia these whirls move at the rate of about 400 miles a day to the east.	Move eastward as in the case of Anticyclones.
The supply of air is maintained by currents in the upper layers of the air, which descend into the inner portions of the whirl; the air supply is not chilled, and rain rarely occurs, so anticyclone weather is bright and calm.	The air ascends in the central portions, expands, and in so doing gets chilled, hence the cyclone is often accompanied by rain and storm.
The anticyclone belt in Australia varies with the seasons, being in 25° south latitude in winter, and 30° in summer.	The cyclone belts lie usually well to the north and south of the anticyclone belt. When they develop in Australia south of the tropic of Capricorn, they usually cause stormy weather.

Southerly Buster.—This is perhaps the most striking local wind in New South Wales, and though similar air currents are not unknown in Melbourne and Adelaide, yet it is felt with most vigour along the coast of New South Wales as far north as Port Stephens. The conditions preceding a Southerly Buster are well known. Usually several hot days occur in succession accompanied by winds from the north and north-west. The weather chart usually indicates that an anti-cyclone, or HIGH, has just left our coast, whilst the succeeding link in the anti-cyclone chain is to be seen with its centre over Perth. According to Mr. Hunt (*vide* Royal Society Proceedings, 1895) this pair of high pressure areas is invariably accompanied by a low V depression, an elongated area of low pressure, on the South, towards which flows the heated air current from the Western Plains of Queensland. As the second anti-cyclone whirl advances, the winds in front of the eddy, which are moving counter-clock-wise, "sweep in a northerly direction and . . . . . on the eastern coast aided by the smaller friction of the ocean and the shelter which the mountains afford from other winds, the southerly becomes more vigorous and rushes northwards in a squall." It is usually accompanied by rain, always by an immediate diminution of temperature of 10° or more, and often attains a velocity of fifty miles an hour. (Fig. 74).

It is very possible, as suggested by Professor David, that the grand elevated westerly air drift may carry one of the supporting columns, *i.e.*, an anti-cyclone, forward over the Main Divide while the column next in succession is blocked in some degree by the same obstruction. One may imagine a "stretching" of the

Col isobars, (to use a concrete analogue) connecting the two anti-cyclones almost beyond their powers of resistance. Finally the accumulated pressure behind the Main Divide rises beyond bounds, and the second anti-cyclone sweeps over the Divide with accelerated velocity, the winds in the fore-front blowing with abnormal intensity, thus constituting the **buster.*** Since the wind used to arrive in Sydney after passing over the Brickfields to the south, it was known as "the Brickfielder"; but this name is now dying out.

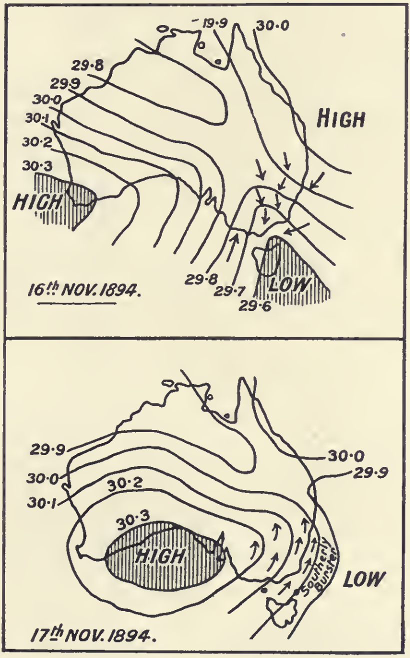

Fig. 74. Southerly "buster" (after H. A. Hunt).

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*Another possible explanation of a "buster" is that it is due to the formation of an elongated trough of relatively warm and therefore light air, following the low-lying coastal plain, and situated between the cool air of the mountain plateau on the west and that overlying the sea on the east.—Editor.

An interesting point in connection with these delayed anti-cyclones is the fact that they sometimes appear to be **deflected somewhat to the north** of their usual path, and finally pass over to the coast by way of the Hunter Valley. This is due to the formation of the Cassilis Geocol, or depression in the Divide, consequent on the erosive action of the Hunter-Goulburn River, which has resulted in a lowering of the Divide by many hundreds of feet. (See Fig. 75).

Tornadoes.—These are severe local storms which often inflict great damage in a comparatively short time. They occur chiefly during warm moist weather when the main directive forces in the wind circulation are temporarily suspended. The chart Fig. 73, (*vide* Hunt, Roy, Soc. Proc., 1895) figures the conditions leading to a tornado at Bourke, the anti-cyclones being abnormally far apart and no definite factor influencing the atmosphere in the Western Plains. The air under these circumstances is in an unstable condition. The locally heated lower layer may rise suddenly, its vapour is condensed, setting free a large amount of heat, which increases its ascensional power. More air rushes in from the lower strata, and a powerful eddy is readily formed, accompanied by huge black clouds, formed by the condensed vapour. This whirling system of low pressure air often travels considerable distances without being dispersed, and exercises a tremendous upward movement on objects with which it comes into contact. On passing over a house the roof is often blown off by the **normal** atmospheric pressure **inside** the building, which is temporarily greatly in excess of the **low** pressure conditions of the tornado.

The tornado traversing North Sydney on 27th March, 1906, which led to the death of one person and seriously injured several others, was of this type. It travelled south-east from Chatswood and died out at Circular Quay, the area affected being about 150 yards wide. In December, 1896, Nevertire was devastated by a tornado; while in 1897 one passed over almost the same area in North Sydney as in 1906, though the maximum effect was felt further south.

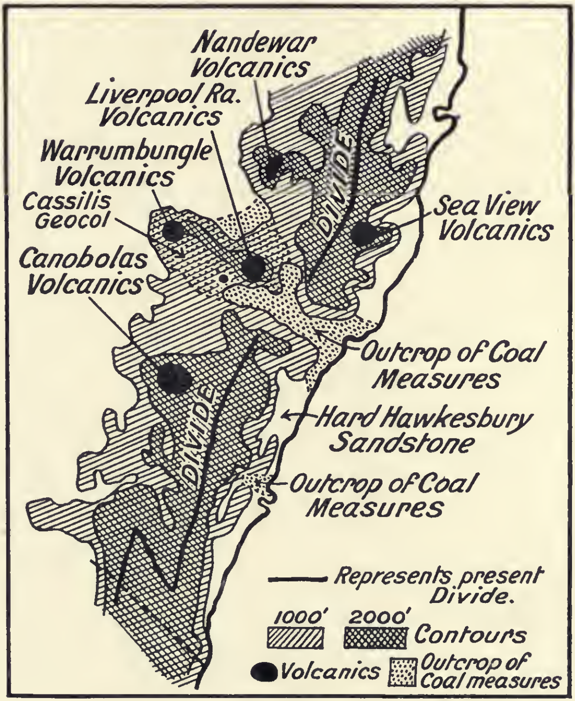

Fig. 75. Cassilis Geocol.

Although popularly tornadoes and cyclones are synonymous, the latter term should be reserved for the infinitely larger areas of low pressure, usually accompanied by rain and but rarely inflicting damage on property, which have been described above as associated with anti-cyclones.

Rainfall in New South Wales.—Water is constantly being evaporated when exposed to ordinary atmospheric conditions. As stated previously, a small variable percentage of water in the form of vapour is always present in the air. The maximum amount of water vapour which can be sustained in the atmosphere varies with the temperature of the latter. The hotter the air the more water it can absorb without reaching the point of saturation or "**Dew Point.**" At 60° F. the air in a room 20ft. x 20ft. x 12ft. could absorb some 3lbs. of water vapour without deposition. If the temperature were increased to 80° F. another 3lbs. of water vapour could be absorbed by the heated air. (Archibald.) Conversely, if the air under the latter condition were cooled 20°, *i.e.*, to 60° F., the excess of water vapour would condense as a mist and form drops of water. On a cold day the moist warm air from the lungs on expiration has the appearance of a mist, owing to the rapid chilling and consequent deposition of that portion of the water which is in excess of what is required for the saturation of the cold air, *e.g.*, at 70° F. a cubic foot of air will retain 8 grains of water.

These facts explain the conditions favourable for rainfall; which may be briefly stated as follows:—The transfer of air containing water vapour. from a point whose temperature is in excess of the **dew point** for that proportion of vapour to a spot where the temperature is below the dew point for the **same** proportion of vapour. **The reduction in temperature is the essential point.** This decrease in temperature is usually brought about in one of two ways:—(*a*) By a horizontal movement of a body of air to a colder latitude, causing a fall of 1° F. for every seventy miles nearer the poles. (*b*) Or a vertical movement of the air to higher regions of the atmosphere, causing a fall of 1° F. for every 300ft. of rise.

Suppose a cubic foot of air containing four grains of water were to form part of a northerly wind blowing from Bourke towards Kiandra. The average temperature of the former is 68° F., and air requires nearly eight grains per cubic foot to be saturated here. On reaching Kiandra, where the temperature is often as low as 45° F., any water in excess of 3.5 grains per cubic foot, is deposited as a mist or cloud. If sufficient water be present these minute droplets collect together, forming larger drops, which, on approaching 1-15th of an inch in diameter, can no longer be supported by the air, and they fall as rain.

The true explanation of the action of **mountains** as "rain gatherers" is now obvious. A warm wind (usually by no means fully saturated with water) will travel for miles over level ground without parting with any moisture. On reaching an elevation the air current is deflected upwards and reaches cooler regions; the new temperature may be below the dew point for the water vapour held in the air, in which case, as before, the excess is deposited as mist or rain. Hence the windward side of a mountain range is usually the wetter, for when this region is passed the air is no longer "supersaturated" for that temperature, and there is no tendency towards further rain.

In New South Wales the area affected by rainfall is determined mainly by horizontal movements of the atmosphere; but the influence of **contour** is paramount in determining the relative amounts of water deposited on various regions.

Owing to the absence of inland seas or lakes, New South Wales derives its rain mainly from the Pacific. A considerable amount, however, especially of the interior rainfall, is derived from the Gulf of Carpentaria and possibly from the Southern Ocean, since our western areas owe their rain chiefly to winds accompanying a col between two anti-cyclones, when the air is sucked in from north and south.

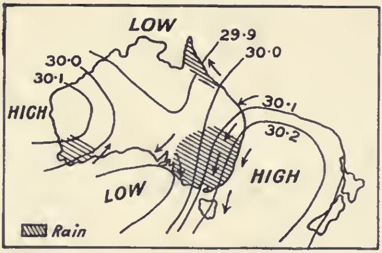

Fig. 76. Isobars leading to Eastern rains, October 16th, 1905.

In October, 1905, a typical rainfall occurred, which may be studied with advantage before considering the average distribution of rain in New South Wales. The isobars at that time denoted a HIGH centred over Perth, while the preceding HIGH, or anti-cyclone was just leaving the continent off Cape Howe on its eastern journey. Between the two lay a **col** of low pressure, which developed next day into a cyclonic eddy with centre over Adelaide. This area of low pressure caused an inflow of moist warm air from the Queensland coast. On reaching the cooler regions of the New South Wales Tableland, etc., these northerly winds deposited their moisture along a belt coinciding roughly with the western flanks of the Great Dividing Range. (Fig. 76.)

For the purpose of the distribution of rain in New South Wales the State may be divided into three major zones—(*a*) Coastal Strip, (*b*) Highlands, (*c*) Western Plains. Section (*b*) Highlands, is not, however, one uniform block, as the elevated area is broken by two well-defined gaps, for which the term **Geo-col** is suggested.* Thus we have the break in the highlands at the head of the Hunter River, known as the **Cassilis Geocol**, and to the south of the Blue Mountains the less

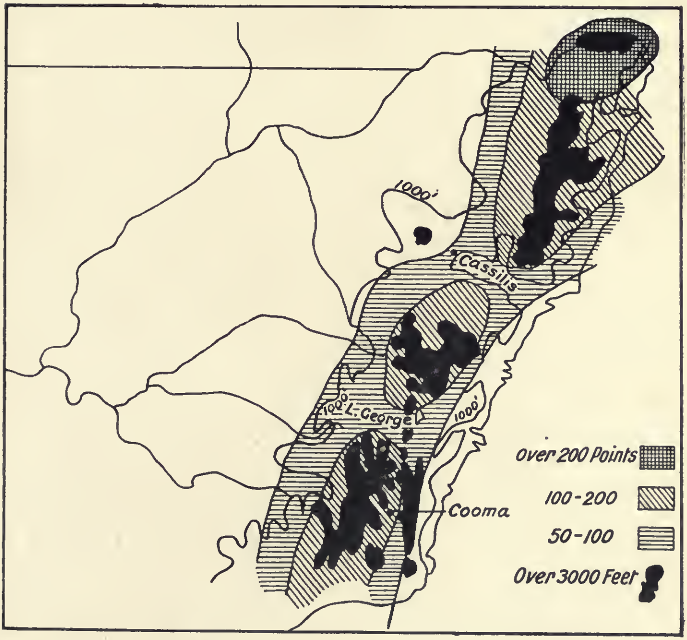

Fig. 77. Relation of Rainfall to Contour.

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*An account of the interdependence of rainfall and Contour in New South Wales will be found in Proc. Linnean Society, N.S.W., 1906, 26th Sept., and this section is based on that paper.

striking gap where the Southern Railway Line crosses, which has been termed the **Lake George Geocol**.

A very close connection exists between the distribution of the annual rainfall and the arrangement of these three land masses. Thus in the sketch map Fig. 77 it will be seen that in the west the rain lines of equal rainfall, known as **isohyets** of 10 inches and 15 inches, are simple curves surrounding the dry interior, and approximately parallel to the outline of the continent. But directly we leave the plains and reach the highlands (1500 feet contour), a remarkable pair of "bulges" is shown by the 25 inch rain-line. One of these extends nearly to Newcastle over the Cassilis Geocol, the other extends over Lake George and down the Snowy Valley. Thus the relative depression in the dividing range has had a very important effect on the rainfall. There has been no up-flow of moist air over these areas, and consequently no chilling and deposition of surplus moisture, as explained in the previous section.

On the other hand, the more elevated portions of the Divide, the Blue Mountains, and Kosciusko, have led to "positive bulges" from the wetter coast towards the dry interior. These two localities have average rainfalls reaching 50 or 60 inches a year. The two chief outliers of the Cordillera on the west, the Canobolas, near Orange, and the Warrumbungles at the head of the Castlereagh River, are also of importance, and have led to a western extension of the 25in. isohyets towards the arid districts.

Accompanying this alternation of wet and dry zones, which may be tabulated from north to south as follows:—

A. Warrumbungle, New England—wet.
B. Cassilis Geocol and Hunter River—dry.
C. Canobolas and Blue Mountains—wet.
D. Lake George Geocol—dry.
E. Kosciusko—wet.
F. Rift Valley—dry.

we have a corresponding difference in the flora of the State. Thus the western trees Wilga and Bull-oak are found in the Hunter Valley, this being the only locality in the **east** of the Divide where such trees flourish.

Isolated rain-storms also show the paramount influence of these three land masses and their intervening geocols. Thus in October, 1905, an area of low-pressure cyclone, or LOW between two anti-cyclones, led to a downrush of heated air from the Queensland coast towards the Victorian border. The first barrier, the Macpherson Range, caused relatively the greatest cooling, so that a precipitation of over 200 points, 2 inches, was recorded.

Not until the Cassilis Geocol is reached do we get less than 100 points. The increased elevation near Bathurst and Canobolas led to a further increase to over 100 points.

Another belt of dry country, coinciding with the Lake George geocol, marks the intimate relation obtaining between rainfall and contour, while the increase over Kosciusko shows that the northern winds still retained too much moisture to be held as vapour at the cool temperatures of the Monaro tableland.

SEASON OF RAINFALL.

A very important factor, in connection with agriculture especially, is the season at which the rain falls. This is not shown on the **Annual** rainfall map. The isohyet for 30 inches passes through Albury, and also close to Moree, but the latter has a maximum rainfall in February, while this is the driest month in Albury! These variations have been charted by the Commonwealth meteorologist, and Fig. 78 is based on his map.

In the **north** of the State by far the wettest months are January and February. In the **south-west** the rain chiefly falls in June. Naturally in the intermediate district—since the country is not influenced by any striking changes in contour—there is a mingling of the two rainy seasons, leading to a uniform rainfall throughout the year. At Dubbo, for instance, the rainfall is about 1¾ inches each month of the year. This variation has little to do with the orography of

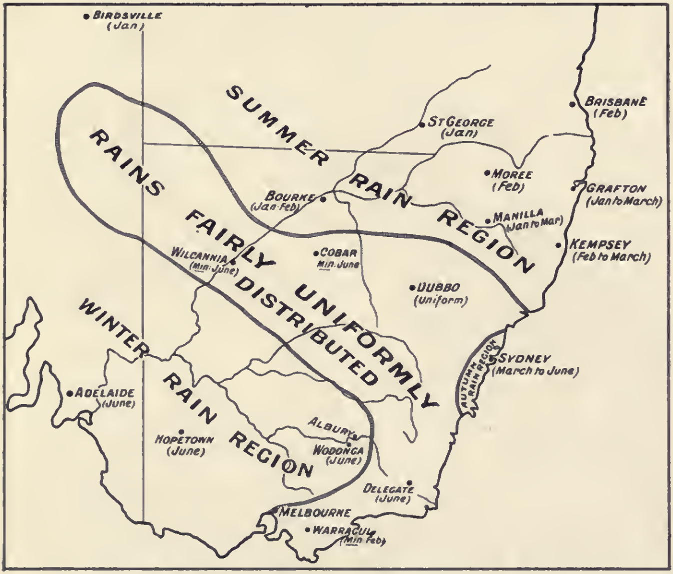

Fig. 78. Map of Seasonal Rainfall (after H. A. Hunt).
Months with *maximum* rainfall are given in brackets. Occasionally a more characteristic minimum (Min) is given.

the State—or the boundaries between the regions would run north and south instead of almost east and west. The explanation depends on the seasonal movement of the sun from Tropic to Tropic. In the southern summer the sun and all **the chief wind systems swing south,** and tropical or monsoonal rains influence Northern Australia. These reach down to about latitude 32° in New South Wales. In winter (June) the sun has moved north, and there is hardly any rainfall in Northern Australia. But the Roaring Forties and accompanying cyclones, etc., move north in unison, and their moisture influences the rainfall as far north as Brisbane. Hence in the overlapping region—though neither the full effect of the southern systems nor of the northern monsoons is felt—there is a certain amount of rainfall derived from both sources. Dubbo may be described as the centre of variation, but the central area indicated on the map (Fig. 78) includes the

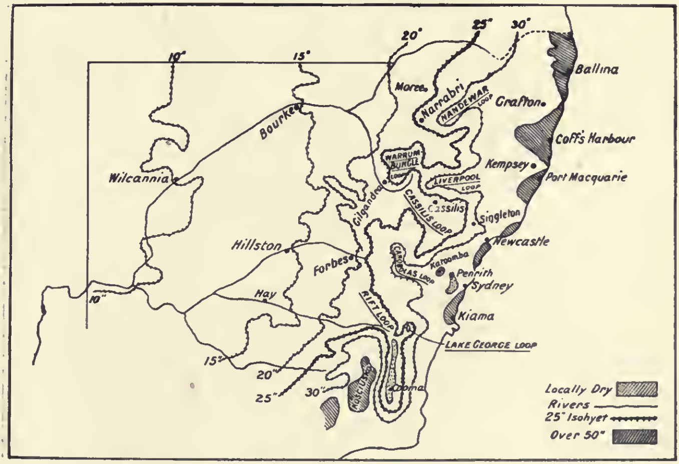

Fig. 79. Map showing average rainfall to the end of 1908 (after H. A. Hunt).

districts which cannot fairly be placed either in the winter or summer rain region.

The autumnal rains, which are characteristic of Sydney (March to June) imply some other factor. These March rains only occur along the East coast where there are high mountains (*i.e.*, at Kempsey and Geraldton). Perhaps they are related to the cooling of these land masses in autumn, which is much more rapid than that of the adjoining water, and would lead to their acting as strong condensers of moist air currents from the sea.

The **annual rainfall** is shown on Fig. 79.

CHAPTER XV.—FLORA AND FAUNA.

(A. H. S. LUCAS.)

Introduction.—Since New South Wales is not separated by natural barriers from the adjacent States the Fauna and Flora have a general Australian character. Australia has been for a long period of time isolated from Asia, and for a still longer period from South Africa and South America. Some of the animals and plants now existing have their nearest allies in India and especially in **Malaysia**, but others have their nearest allies in **South Africa** or in **South America**, while owing to the long isolation from all other lands yet other forms have developed which are peculiar to Australia. Thus the Emu and Cassowary in Queensland, belong to the family of **gigantic flightless birds**, of which the Ostrich survives in Africa, the Rhea in South America, while the Moas survived in New Zealand until the advent of the Maoris. Since the Ostrich persists in spite of the presence of the Lion and

Leopard, and the Rhea in the face of the Jaguar and Puma, it is no wonder that the Emu persists in Australia, which has not been reached by any of the great Felidae. The only part of the world in which **marsupials** are still living, apart from the islands to the North of Australia, is the American Continent from the Southern United States to Patagonia. The freshwater Tortoise, the native Trout (*Galaxias*) among the fishes, one of the groups of Frogs, and some of the Earthworms, also have their nearest allies in South America.

Wattles are abundant in South Africa; the Boronias of Australia correspond to the Buckus of the Cape, and the Australian Heaths (*Epacris*) correspond to the true Heaths (*Erica*) of the same region. But the greater number of both plants and animals seem to point to an Asiatic origin. Thus the Dingo represents the Wolves; the Rats and the Bats, both fruit and insect eating, belong to Asiatic types; and most of the Birds, *e.g.*, the Rails and Quails, all the Lizards, the Snakes, the fresh water Crayfish, and the bulk of the Insects are much more closely connected with Old World forms than with New. And so with those giant Myrtles, the Eucalypts. In the case of the plants, migration has continued along the tract now broken by Torres Strait until more recent times, and the migrants, such as the Palms, Birdsnest and Staghorn Ferns, and the gigantic Spear Lily have reached far South along the most Eastern Coastline of Australia. Animals have accompanied the plants, such as the only true *Rana*, the Sunbirds, which represent the Humming birds of the New World, and the Jabiru, a large bird of the Stork family, which was formerly met with as far South as Botany

Bay. Even nowadays flocks of Papuan birds and swarms of Papuan Butterflies come over to Cape York.

With the exception of some of the latter migrants, the plants and animals have long been isolated, and many peculiar forms have been evolved. The most ancient of all the Mammals are the Platypus and the Ant-eater (*Echidna*). These are so little removed from a reptilian origin as to have retained the character of laying eggs in nests and so producing their young. The Platypus has become so peculiarly adapted to an aquatic, and the Echidna to a burrowing life that their relationship has been entirely masked by the great differences in their snouts, their feet, and the covering of their skins. The Marsupials have produced types which represent nearly all the classes of the higher mammals of other parts of the globe. In relation to their habits of feeding on the honey of the Eucalypts the Brush-tongued Lories have developed a tongue of altogether peculiar structure, quite unlike that of the other parrots of Australia and of all the rest of the world. The Cockatoos too are peculiar to Australia. The Honey-eater is another characteristically Australian family of birds. While this specialization has proceeded over the whole of the Continent it has been specially marked in the South-West which has been not merely isolated from Asia, but also from the rest of Australia, during geological periods.

FAUNA.

Mammals.—The indigenous mammals of New South Wales belong to three groups. There are the Platypus and Echidna forming the **Prototheria** or Egg-laying Mammals, the **Marsupials**, in which the young are born in an exceedingly immature state, and are attached to the nipples of the mother in a special pouch formed by a fold of the skin; and the **Higher Theria**, in which the young are born in a well developed state and have no need to be attached to the mother and carried in a pouch.

The Platypus is found in the Eastern rivers. The tail is broad and flattened, and the feet are webbed. The fur is short, dense and velvety, and serves to keep out the water as does that of the Seal. The muzzle is a broad flattened beak, with a soft sensitive skin, and with this it obtains its food by grubbing in the soft mud of the banks. It feeds at dawn and dusk. The burrow is excavated by means of the strong claws which project beyond the web; it opens below the water, but ends at a higher level in a rounded apartment, which is lined with grass and leaves, and in which the eggs, 1 to 4, are laid. These have a leathery coat or shell in which there is, however, very little carbonate of lime. The Echidna, on the other hand, has a long slender beak, with a long and extensile tongue, no web to the feet, and the body is covered with fur mixed with stout spines. It is a much more powerful animal than the Platypus, and with its strong muscles and strong claws soon excavates a burrow in hard ground. The Echidna feeds on ants and their eggs, and breaks up the nests with his powerful claws. Neither animal has teeth when adult, but the young Platypus has at first teeth which are afterwards shed, and the gums then form the hard horny plates with which the animal crushes the shell-fish on which it feeds.

The Marsupials belong to two groups,—the **Diprotodonts**, with two long powerful incisors in the lower jaw, one on each side, and the **Polyprotodonts**, with numerous incisor teeth on either side of both jaws. The former are adapted for a herbivorous diet, the latter for a carnivorous, insectivorous or mixed diet. The Diprotodonts include the Kangaroos and Wallabies and the Rat-Kangaroos, the Wombats, and the Phalangers, or Australian Opossums. The **Kangaroos** feed on herbage, and take the place of the Deer and Antelopes of the rest of the world. Both Kangaroos and Wallabies,—the distinction is practically only one of size—were formerly extremely abundant. Thus Barallier wrote in 1802, of the country north of Bowral, "The hills are covered with Kangaroos, which resemble a flock of goats grazing peacefully, and offer to the eye a pleasing pastoral picture." Of the same locality Mr. Cambage writes that in 1886 it was "literally alive with rock-wallabies." The advent of the white man with his sheep and cattle has altered all this. The animals are killed for their skins, over half a million skins of Kangaroos and Wallabies passing through the Sydney centre in 1908. And they are destroyed in order that the domestic animals may enjoy their pastures. This may be inevitable in great part, but surely we may reserve some corners of refuge for these innocent and interesting creatures. The largest Kangaroos are the grey, the commonest, the Red Kangaroo of the plains of which the female is called the Blue Doe or Flyer, and the Wallaroo or Euro. A big Old Man Kangaroo can clear thirty feet in a leap. The Rock Wallabies are wonderfully adroit on the ledges of the rocks, as sure-footed as the goat. There are several other kinds of Wallaby, as the Bridled, the Red-necked, the Black-tailed, and the little Pademelon. (Fig. 80.)

The **Wombats** have a sturdy form, stout skeleton, powerful muscles and short limbs with strong digging claws. They burrow in the hard ground of the rock country. In the day time they rest in the burrow, and at night emerge to feed on the herbage, and may, if plentiful, do harm to the settlers' crops. The

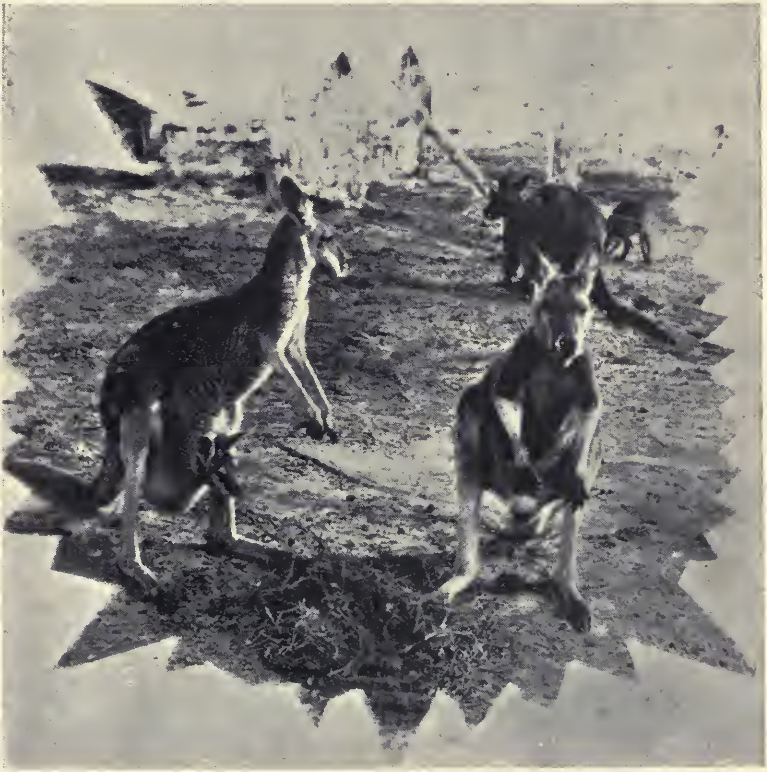

Fig. 80. Red Kangaroo—male, female, young in pouch. Wallaroo in background.

Phalangers are arboreal, feeding on the leaves of trees and on fruits if they can get them. They are commonly called Opossums, but the true American Opossums are carnivorous and have polyprotodont teeth. The fur is excellent for rugs, and two million or so are exported every year. At this rate the time for extermination cannot be far distant. The Ring-tailed Opossum is a smaller animal, with the end of the tail white and hairless. All the Opossums use the tail to take hold of the branches, but the Ring-tail is most prehensile of all. The Flying Opossums possess an extension of the skin of the flanks in the form of a membrane, and are thus enabled to take short flights from tree to tree. The **Koala**, or **Native Bear**, is allied to the Opossums. It is quite harmless, and the fur is of little value, and as the Bear feeds only on gum leaves, one may surely plead for its preservation. (Fig. 81.)

Among the Polyprotodonts are the spotted **Native Cats**, which are destructive in hen roosts, the little **Pouched Mice** and the **Bandicoots**. The last are ground animals, burrowers and omnivorous. (Fig. 82.)

The **Eu-Theria**, or Higher Mammals, comprise the Dingo, a true wolf, the Seals and Whales of the seas, and the Rats and Bats. The Dingo antedates the blackfellow, and has never been really tamed. It is an expert hunter, running down its prey, or springing upon it from ambush. It plays havoc amongst sheep and even attacks calves. Whales pass up and down our coast to breed in the North. A few are captured in Two-fold Bay, where they are driven in by the Killer, another kind of Whale, with powerful teeth, which preys upon Dolphins, Seals, and other whales. Dolphins are often seen off the coast and in the harbours, tumbling and gambolling about the vessels. They keep in schools and feed on the shoals of herrings and other fish. A few Seals are still preserved on the Seal Rocks, north of Newcastle. There are many kinds of **Rat**, the most interesting being the Water Rats, and the Jerboa or leaping Rats of the interior. The smaller insect-feeding Bats hunt their prey by night, hanging suspended in hollow trees or caves during the day-time. The larger Fruit-eating Bats, or Flying Foxes, migrate from spot to spot as the fruit ripens. Their shrill cries are often heard around Sydney, as they congregate in numbers on the Moreton Bay figs.

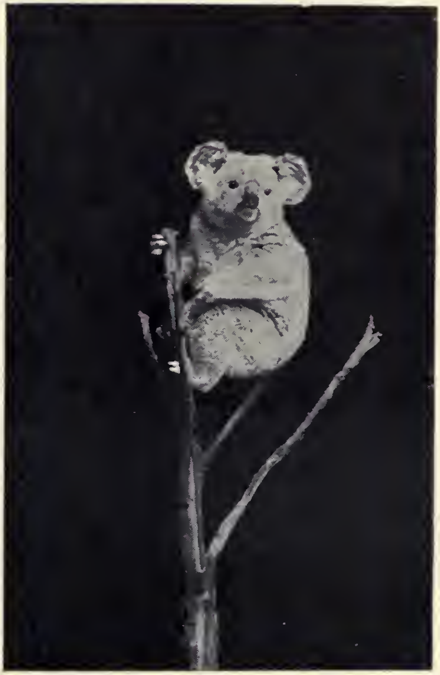

Fig 81. Young Native Bear.

Man has stocked New South Wales with horses, sheep and cattle, pigs and poultry. All have thriven remarkably well in the new country, and stand the climate even of the plains. In years of severe drought, however, millions of sheep and large numbers of cattle, lose their lives owing to the lack of grass and of water. Alas, too, the Rabbit and the Fox have been introduced. Both have spread and multiplied with extraordinary quickness; the Rabbit has proved a more formidable rival to the sheep than all the Kangaroos and Wallabies put together, and the Fox is more destructive already than the Dingo. The results of the introduction of these vermin, together with the Common Snail, the Sparrow and the Starling, show what miserable blunders man is capable of perpetrating when he interferes without knowledge in the economy of nature.

Birds.—New South Wales before the advent of the white man, was richly endowed with bird life of wonderful variety and interest. The woods abounded with Cockatoos, Lories and Parrakeets of brilliant colours, whilst amongst the foliage were swarms of Honey-eaters, and a multitude of other birds remarkable for their plumage or their notes. The watercourses and lagoons were covered with countless waterfowl, Swans and Pelicans, Ducks, Grebes, Coots and Waterhens; while amongst the waders were several kinds of Herons and the graceful Ibis, with her fatal gift of beautiful plumes. Flocks of Emus, Native Companions (the only true Crane Australia possesses) and Bustards roamed over the plains. The Mallee Hen and the Brush Turkey built up the extraordinary mounds on the summit of which they heaped up leaves to form a natural incubator for their eggs. Lyre-birds, even around Sydney, filled the gullies with their song, not only piping their own liquid notes but artistically mimicking

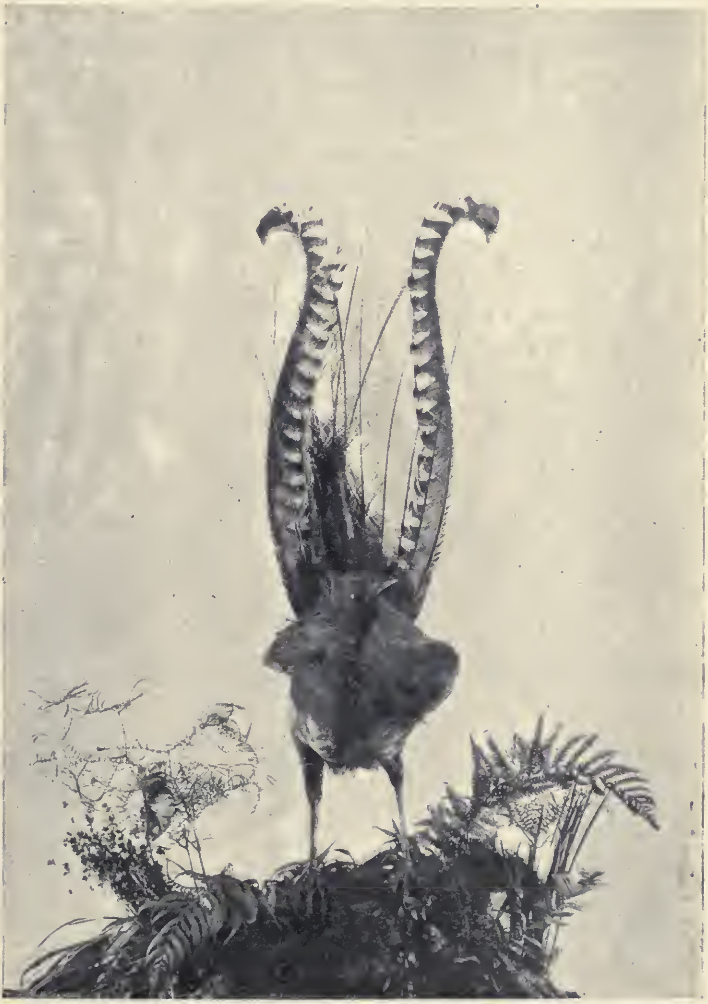

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Fig. 82. Lyre-bird: *Menura superba*

those of the other birds, whilst the males spread their beautiful tails for the admiration of their mates. In secluded gullies, too, the Satin Bower-bird made his playground or bower with overarching boughs, and adorned the platform of sticks within with small bones bleached white, berries, shells and shining leaves.

But the birds have been sadly destroyed by the gun and by the bush fires, and by poison laid for the dingo, while the domestic cat and the fox have assisted man in the destruction. Still, though some of the more remarkable birds are now rare, a great number remain to delight and to serve us. For many of the inland birds live entirely, and most live partially, on insects; and noxious insects are the most serious foes with which the farmer and the orchardist have to contend. It is not merely cruel, it is stupid, to wantonly destroy the Robins, Tits, Thrushes, Blue Wrens, Ground Larks, and most of the Honey-eaters, for the birds are the very best friends of the agriculturalist.

The birds which are most characteristically Australian are the Emu, the Lyre-bird, the Mound builders, the Bower-birds, the Brush-tongued Lorikeets and the Honey-eaters. The Lorikeets travel in flocks from place to place as the Eucalypti come into flower, insert their brush-like tongues into the blossoms, and withdraw them covered with nectar and small insects. The Honey-eaters include larger forms like the Gill-birds, which are shot for food, and many of the most frequently seen smaller birds. It is curious that no birds of the Pheasant and Grouse families, so abundant in Asia, have reached Australia.

Amongst the birds conspicuous for their plumage are the Rifle-bird of the brushes of the Northern Rivers, rich velvety-black and metallic green; the Regent-bird, the male clad in deep velvety-black with a golden crown; the Satin Bower-bird, the male in deep shining blue-black satin, with light blue eyes; the magnificent Purple-breasted Fruit Pigeon; the male Lyre-bird; the Cockatoos and Parrots; and amongst smaller birds, the Blue Wrens, Robins and Finches, and the Azure Kingfisher. The Lyre-bird leads in song, but the Magpie, the Reed Warblers, the Harmonious Shrike Thrush, the Crested Bell-bird and the Bell Minah, the Butcher-bird, the Coach-whip, the Yellow-faced and the Sonorous Honey-eaters, form a native choir which might compete on equal terms with a similar assemblage of birds from any other region in the world. For it is a libel to say that Australian birds are songless. It is true that the birds are quiet as they rest during the heat of the day, but at feeding time, at dawn and in the evening, and particularly in the months of spring, the woods and gullies are full of melody.

The **Birds of Prey** are not present in excessive numbers, but all groups are represented except the Vultures. The Wedge-tailed Eagle is the largest Eagle in the world, and is seen at his best as he circles over the gorges of the mountains. There are Harriers, Kites, Falcons and Buzzards, the smallest being the little Sparrow-hawk. There are several kinds of Owls, but as these birds prey by night they are less frequently seen. The little Boobook Owl is often heard uttering his peculiar cry of More-pork or Mo-pork, though the cry is often wrongly attributed to another nocturnal bird, the Frogmouth or Podargus.

The **Sea birds** include the Albatrosses, two kinds of Gull, the diving Gannets, many Petrels and Terns. In marked contrast to New Zealand only two Penguins, the Crested and the Little Penguin, breed on our coasts. The Penguins are confined to the Southern Hemisphere, and to the colder seas, being the most conspicuous birds which frequent the shores of the Antarctic Continent. The wings have become so small and feeble that they are useless for flight, but the birds are experts in diving and swimming. They have been seen 1,200 miles from the nearest land, although they cannot fly a yard.

Only a few foreign birds have been introduced and liberated in New South Wales. The Sparrow follows settlement everywhere, but fortunately does not appear to stray far into the bush. The Starling is abundant about the main centres. Indian Doves have established themselves around Sydney, and there are a few Skylarks and Thrushes, but these spread with extreme slowness.

Reptiles.—In the rivers are a few Water Tortoises which excavate holes in the banks in which to deposit their rather large white eggs. But the Reptiles most commonly met with are the **Snakes** and the **Lizards**. Some of the Snakes are venomous and possessed of poison fangs, but others are not. The most dangerous are the Tiger Snake, always ready to show fight; the Death Adder, which is too sluggish to get out of your way, and possesses the longest fangs of any; the Black Snake, which is a good swimmer, and may be encountered by bathers; and the Brown Snake, which is one of the commonest. The Copper-head, a dark coloured Snake, is plentiful in the Southern Highlands. All the Sea-Snakes are venomous, but these are tropical, and are rarely found straying south as far as Sydney. The non-venomous Snakes are the Pythons, the Tree

Snakes and the burrowing Blind Snakes. The Pythons are the large Carpet and Diamond Snakes. They kill their prey by throwing a few coils around it and crushing it. They are really tree Snakes, but rest on the ground during the day. They are interesting because the female takes care of the eggs, helping to hatch them. The Green and the Brown Tree Snakes are, the former absolutely, and the latter practically, harmless. The Blind Snakes live underground and feed on ants and their eggs. The Black and White Ringed Snake is also incapable of biting.

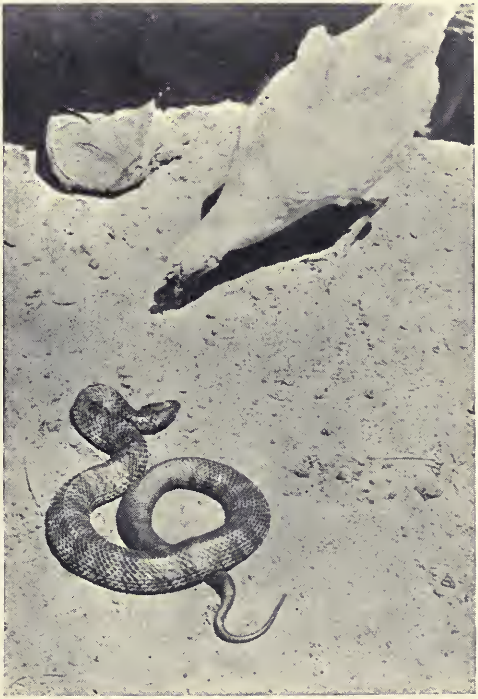


Fig. 83. Tiger Snake.

None of the Lizards are in any way poisonous. The largest are the Monitors, "Iguanas" falsely so called, which ravage the poultry yards. They have forked tongues as have the Snakes, but they have no fangs with poison glands. The true Iguanas are American Lizards, and amongst many other differences their tongue is not forked. The Monitors may be seen in the forest corkscrewing round the trunks of the trees. The bite is severe but not poisonous. The Blue-tongued Lizards are found on the ground; they have a prussian-blue flat tongue, and are not very active. They are the largest of the Skink Lizards, which have smooth scales round the body, and fragile tails, which can be easily snapped off but will readily grow again. The Dragons are Lizards with rough scales and long tails which do not snap off, but assist the animals in climbing amongst the rocks and logs. The Geckoes are Lizards, with fleshy skins without scales, and with curious pads on the toes which enable them to hold on to the vertical faces of the rocks or even to the roofs of caves. Another group of Lizards have lost their limbs, and wriggle along like snakes. They are usually mistaken in fact for snakes, and suffer accordingly, although they are perfectly inoffensive.

Amphibians.—Australia has no Newts or tailed Amphibia. New South Wales, however, possesses the greatest number of Frogs and Toads of any of the States. There are three families. The **Tree Frogs**, which have flat discs at the tips of the fingers and toes, by means of which some of them as the Great Green Frog can climb up the panes of glass in the windows. Many of the Tree Frogs however have lost this power, the discs are small, and the Frogs have taken to an aquatic life.

The commonest is the Golden Bull Frog, which appears in numbers in the water-holes after a rainy spell. The **Toads** are small. They have short limbs and are adapted for burrowing. They do not enter water at all, but deposit their spawn in moist places. The Cross-bearing Toad with a red cross on the back sometimes appears in enormous numbers on the Western plains after heavy rains. The other group of Frogs, the **Cystignathids**, has its nearest allies in South America. The most interesting is the Water-holding Frog, which is found in the Western plains, and even survives in fair abundance in the arid Centre of Australia. As the pools dry up the Frogs burrow in the soft mud, fill themselves up with water, and rest asleep until a rainy season comes again. The blacks know where to find them, dig them out, and make use of this strange water supply.

Sea Fish occur in great variety over the Continental shelf. Sharks are too numerous, making bathing in the harbours outside the baths dangerous, especially in the summer. The largest is the White Pointer, which may attain to a length of 36 feet, but equally dangerous are the Blue Pointer and Grey Nurse, of 10 or 12 feet. The most peculiar form is the one called by Governor Phillip the **Port Jackson Shark**. There are two kinds; both are about four feet long, and are not provided with the usual sharp cutting teeth, but the mouth is lined with a pavement of flat teeth which the shark uses as a mill for crushing molluscs and crustaceans. Teeth of the kind are found in some of the geological strata of Europe, and so it seems that a very ancient type has been preserved in our seas. Other interesting Cartilaginous fish, those whose skeleton is not bony, are the Hammer-head, the Carpet, and a small Saw-fish, among the Sharks, and the Fiddler, the Sting, and the Torpedo Rays. The latter is capable of giving a very unpleasant electric shock if handled or trodden upon.

The bony fishes which are most useful for food are the Schnapper, Bream, Whiting, Flathead, Garfish, Mullet, Rock Cod and the various kinds of Soles and Flounders. Other interesting fish are the gorgeously-coloured Parrot Fish, the Leather Jackets, the Flying Gurnards, the Pipe Fish, the little Sea-Horses and Sea Dragon, and the beautifully coloured Trunk Fishes which are incased as it were in a box made of closely fitting bony scales. The curious little Lancelet, the lowest and least developed type of fish known is occasionally dredged on sandy bottoms. It has no backbone or skull or brains, and the heart is merely a simple tube.

New South Wales is not well off for fresh water fish. Those of the Murray River and its tributaries form a special group, and most of them are edible though more reach the Melbourne than the Sydney market. The Murray Cod is a large fish and may reach 120lbs. in weight. It also occurs in the head waters of the Northern Rivers. The Golden and the Silver Perch are also market fishes. The Cat-fish is abundant, and is appreciated by the Cormorants (Shags) if not by man. Eels are found in the Eastern rivers, but not in the Murray. Species of the little native Trout (*Galaxias*), have been found on the coast from Sydney southwards and in the Snowy River, but are more abundant in South Victoria and Tasmania. The genus occurs also in South America. European Trout have been introduced into the Snowy River and other streams.

It is impossible in our limited space to give a systematic account of the **Invertebrate Fauna** of the State. The simple forms of animals, both terrestrial and marine, which possess no backbone, but are built up on other types of structure, are as rich in variety and interest as the more conspicuous Vertebrates. On the land are a host of Spiders, Centipedes, Scorpions and of the various Orders of Insects. Amongst these are numerous kinds of Butterflies and Moths, which pass through the interesting series of metamorphoses, egg, larva or caterpillar, pupa and mature insect or imago; Bees, Wasps and Hornets, with many forms of nest; ubiquitous Ants, which turn over the soil, bringing the small fragments of stone to the surface; Termites or White Ants, so destructive to timber; Grasshoppers and Locusts, so destructive to crops; the summer chirping Cicadas, wrongly called "Locusts"; and the multitude of Beetles, some of which, as the Buprestids, are beautifully coloured and marked, and all of which are cunningly adapted to various modes of life. Then there are Land Leeches in the damp gullies, ribbon-like Planarian Worms of brilliant colours, the ancient form Peripatus, and local species of Earth-worms. Snails and Slugs are not numerous on the whole, as the general conditions of the State are those of a hot and dry climate.

The harbours and the shores abound in **Marine** life. Starfish, Sea Urchins, Brittle Stars creep over the sea floor; Crabs and small fish hide among the green and brown sea-weeds; here and there an Octopus spreads his arms to capture unsuspecting prey. Molluscs, with spiral or with bivalve shells, or naked with no visible shell at all, are abundant, the various kinds affecting each its peculiar home and hunting ground. The genera

Trigonia and *Lima* recall Oolitic days of the geologic Past, as does the Lamp-Shell, *Terebratula*, an ancient Brachiopod (kind of worm), which nidulates under overhanging rock. Pelagic forms, as the Portuguese Man of War, *Velella* and the snail *Ianthina*, all blue as of the ocean, are cast up after gales from the N.E. Hydrozoa, Polyzoa and even Corals are not wanting. The Sea-life is of perpetual interest.

FLORA.

New South Wales extends over a vast area. The coastal strip, the Highland Plateau and the Western Plains are all continuous respectively with similar country in the adjoining States. There are great differences in latitude and altitude, in rainfall and in distance from the sea, and the geological strata which furnish the various subsoils are many and diverse. Hence the groups of plants which are met with are exceedingly varied, and it is very difficult to divide the State up into natural botanical districts without going into too great detail for this work. In a general way we may distinguish the coastal slopes to the East of the Highland Plateau, the Highland Plateau itself and the Plains to the West. On the North the **Coastal strip** is continuous with that of Queensland, and the climate is subtropical. Hence there is a profusion of subtropical and even tropical trees and plants, forming in suitable places as at the heads of the rivers, jungles or "**brushes**" of matted forest with Palms, Pencil Cedars, Rosewood, Red Cedar, Moreton Bay Chestnut, Silky Oak, Tulip Wood and Moreton Bay Pine (Araucaria), and more open forests of valuable Eucalypts such as Tallow-wood. Ironbark, Spotted Gum and Red

Mahogany, with flowering shrubs and beautiful lily-like Amaryllids growing amongst them.

Where the Hawkesbury sandstone occurs, as around Sydney, there is a peculiarly rich and beautiful flora, bright with *Boronias* and *Eriostemons,* Heaths and Flannel flowers, Christmas Bush and Christmas Bells, and untold multitudes of pea-shaped flowers (*Leguminosæ*) as the *Dillwynias, Pultenæas, Bossiæas,* of all shades of yellow and orange, the blue *Hoveas* and pink Indigo, and the trailing blue and red *Kennedyas.* Among shrubs the various *Proteaceæ,* Honey-suckles (*Banksia*), *Grevilleas* and Geebungs (*Persoonia*) are conspicuous, while the gorgeous Waratah is not yet exterminated by ruthless destruction. Here is the greatest variety of Eucalypts, abounding in honey-laden blossoms, Bloodwood, Swamp Mahogany, White Gum and the species of *Angophora* (Apple Tree), which support a great number of highly-coloured beetles and butterflies.

The **Highland Plateau** from a botanical point of view may be divided into three regions, New England, the Blue Mountains and the Southern Highlands. The average elevation of New England is 3,500 feet, and in winter severe cold is experienced. The geological formations consist of granitic and metamorphic rocks with extensive coverings of trap and basalt. The soil is in general rich, except on the granite hills, and carries a natural flora with special species of Eucalypts and Acacias, shrubby Leguminosæ, and Tea Tree and Bottle brush, and Daisies and Everlastings. The Blue Mountains constitute a Hawkesbury Sandstone area, resting on a Permo-Carboniferous foundation, and capped here and there with basalt. On the surface of the Plateau then the plants which are conspicuous about Sydney reappear, while there are a few *Grevilleas, Boronias* and others which are peculiar. Where the basalt overlies the sandstone the flora is especially rich. In the gullies Sassafras, Coachwood and Tree Ferns have their home. Toward the South the vegetation gradually changes, until in the heights of the Kosciusko district a truly Alpine flora appears. On Mount Kosciusko the tree line reaches a height of about 5,500 feet, and above this level there are morasses and plains broken by piles of granite and watered by innumerable icy streams. Here appear yellow and white Buttercups, fragrant Swamp Epacrids, Forget-me-nots, the woolly Daisy (*Celmisia*), a woolly Lily (*Astelia*) and numerous cushion like growths, mostly of woolly Compositæ, while a rich broad bladed grass (*Danthonia robusta*) and the native Celery (*Aciphylla*) furnish grazing for the sheep brought up from the summer-dry lowlands. It is curious to notice how the same species alters its habit as it ascends the mountain. Below luxuriant and smooth, above it becomes dwarfed and spreading to support the weight of the winter snow, and covered with woolly hairs to protect it from the frosts in winter and the excessive heat of the clear summer sun.

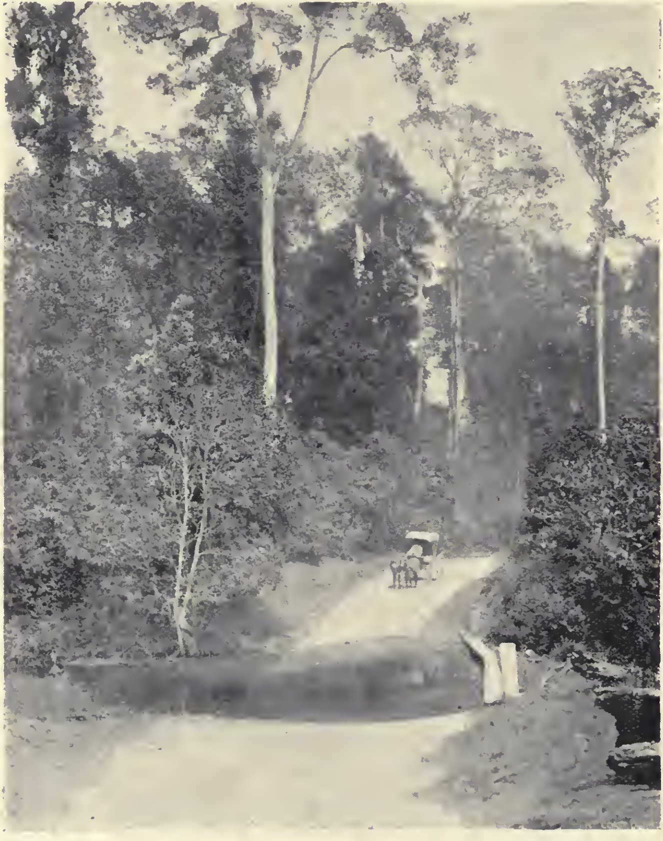
As we descend the Western slopes of the Plateau the trees diminish in size, and are replaced by small, shrubby Eucalypts, the various Mallees, and the Acacia scrubs, Mulga and Brigalow, while the hills may be covered with woods of native Pines (*Frenela*). The **Plains** themselves become veritable flower prairies of Amaranths, Everlastings, Daisies, and other Compositæ, with the gorgeous Desert Pea (*Clianthus*) and the

Purple Darling Pea (*Swainsonia*), and the Darling Lily. Golden Cassias produce a profusion of blooms for a great part of the year, while scarlet, rose, blue, and white *Eremophilas* make a valiant display of colour. Blue, Mitchell and Windmill grasses furnish an excellent fodder, while the many kinds of Salt-bush (*Atriplex*, &c.) possess a marvellous power of resistance to drought conditions, and are greedily eaten by stock of all kinds. If by unwise overstocking these are eaten out, the land becomes a dust-heap, and the country, which if judiciously used would support thousands of domestic animals, becomes useless.

Locally, too, there are assemblages of plants which affect particular habitats. Thus there are some which are strictly maritime, clinging to the seashore, such as the Sea Lavender and the Sea Rocket; some which live only in swamps, as the Sundews; plants of the open forest, plants of the gullies, plants of the moors, plants of the gorges, plants of the plains; and strictly aquatic plants, found in the rivers and water-holes. Changes too in the geological nature of the ground are accompanied by corresponding changes in the flora.

New South Wales, with the rest of Australia, has been so long isolated, that the flora has become remarkably adapted to the climatic conditions. The several factors in the climate are the irregular and in parts scanty rains, and the consequent droughts with long exposure to brilliant sunshine. Hence, especially in the plains, the plants have become drought-resisting in various ways. Instead of the broad succulent foliage leaves of moist temperate regions, the plants are provided with narrow hard leaves with but scant surface and consisting mainly of the fibres of the veins, with a tough Acacias (Wattles) the true leaves only develop in the leaves, is reduced to a minimum. In most of the Acacias (Wattles) the true leaves only develop in the seedling plants; in the adult plant these are lost, the leaf-stalk remaining in a flat, leaf-like form (*phyllode*). In some plants such as the Native Cherry (*Ectocarpus*) and Native Currant (*Leptomeria*) the leaves are reduced to minute scales, which soon fall off, and in the Sheoaks (*Casuarina*) they are replaced by circlets of minute scales. In these cases the branches themselves have to carry out the functions of the leaves. In many plants the tips of the leaves are reduced to spines. In several, as the Prickly Box, many of the branches appear as spines. The shrubs of the bush are indeed, in general, prickly or spiny. In a few the leaves are varnished with a thin layer of resin, and so protected from evaporation. In some of the desert plants the same end is attained by a dense covering of hairs over the leaves or the whole plant. It is remarkable how speedily the native scrub recovers from the effects of a bush fire, the green shoots springing vigorously among the charred stumps. In a few months the country is green again.

The bush supplies but little that appears edible to the white man, but the aborigines made considerable use of native fruits and roots and an occasional vegetable. Among the fruits employed were the Quandong, Native Cherry, Native Currant, Capers, Figs, Wild Raspberries, Geebungs, Five-Corners and a native Tomato. The tubers of the terrestrial orchids and the pseudobulbs of some of those growing on rocks and trees, the bulbs of the Darling Lily, the tubers of a few grasses and sedges, were mostly roasted before eating. Seeds like those of the Burrawong (*Macrozamia*) and Nardoo (*Marsilea*) were ground, and those of several grasses were ground and made into cakes. The succulent Saltbushes and Pig's Face (*Mesembryanthemum*) were



Tourist Bureau, N.S.W.

Fig. 84. Eucalyptus Forest, Doramble Crossing, Brunswick River at Billinugel, North Coast District.

eaten as vegetables. Gum and Manna were obtained from some of the Wattles and Eucalypts respectively. (F. Turner).

The **timbers** of Australia are the most important product of the native vegetation. Rose-wood, Cedar, Sassafras are highly ornamental soft woods. But the Eucalypts are a national asset of the highest importance. Nowhere else in the world are there forests of such useful trees as these gigantic Myrtles. (Fig. 84.) The hardwoods are denser and more durable than Oak and Teak. And they are not slow-growing. A gum of 24 years growth would yield timber of equal bulk to that of an Oak 200 years old. A pine tree (and most of the American and Canadian timbers are pines of some kind) if cut down is killed and must be replaced. But a Eucalypt if cut down only grows again, and is ready for cutting again after a few years. (Baker). If properly conserved, and not wantonly destroyed, the Eucalypts will continue to yield to Australia all the wood for sleepers, wood-paving, telegraph poles, joists and flooring that will be required, with a liberal surplus for export. The chemical constituents of the oils are extremely varied and valuable. The oils of some species yield the basis of perfumes. That of one at least is nearly pure turpentine. From the trees acetic acid, alcohol, formalin and other chemicals can be obtained by destructive distillation, and the residual charcoal is in great demand for use in the new suction gas engines and for other purposes. Strange to say, the value of the Eucalypts is recognised and appreciated for more completely in America than in Australia. The trees are grown not merely for their timber and oils. One may safely say that more Eucalypts are cultivated in California than in the whole of Australia. Mr. Baker quotes an instance where an American farmer had given over his wheat-fields, to the extent of 70,000 acres, to the growth of gums and derived a better profit from them than from the wheat.

When the lands are necessary for agricultural purposes, the forests must go. But they should be carefully maintained in the Ranges and especially around the heads of the water-courses where they regulate the drainage of the country, and prevent floods in the lowlands. The kinds which will endure the climate should be planted as shelter belts in the plains. None of the valuable species should be ruthlessly exterminated by wholesale ring-barking and fire. Wholesale destruction of forests means the ruin of the agricultural industries, whereas wise conservation and wise planting mean the perpetuity of these industries, and a perpetual supply of wood for all purposes.

In good country when the forests are judiciously thinned and partial clearings are made, room is provided for the orchardist and the general farmer. On the plains where water shall have been secured for irrigation purposes wheat and other cereals can be grown in abundance and with profit. There is no reason why New South Wales should not produce sufficient wheat, fruit and vegetables for any population which may be settled within her borders. On the northern rivers, especially near the coast, the Sugar Cane flourishes, and probably other subtropical products could be obtained. Our fruits range from the tropical banana and pine-apple to the fruits of the cold temperate regions, apples, pears, plums, cherries, strawberries, raspberries. gooseberries, while between we have the finest oranges and grapes. What ample supplies of vegetables can be produced is seen in the Chinamen's gardens. With scientific farming, and a proper care for the native timbers, grasses and salt-bushes, and with irrigation, the capacities of the soil and climate should render New South Wales one of the most flourishing and productive States in the world.

PART III.—ECONOMICAL AND POLITICAL GEOGRAPHY.

CHAPTER XVI.—WATER-SUPPLY, AND ITS RELATION TO SETTLEMENT.

(A. W. JOSE.)

There are very few patches of infertile soil in New South Wales. The difference between rich and barren lands is made, not by the quality of the soil, but by the amount and regularity of the water-supply. A dry year in Illawarra spells ruin: good rains west of the Darling would fit the greater part of the country there for dairying—if only the water could be conserved and distributed at the right times of year.

That brings in the second factor of natural water-supply. Not many countries in the world enjoy a really regular rainfall; but in most their physical formation allows the usefulness of a wet day to be spread over succeeding weeks. The greater part of Eastern England, for instance, has an annual rainfall of 23.4in. But any particular storm soaks a wide area of spongy alluvial soil, through which it slowly makes its way to slow-flowing rivers; underlying the river-beds is a layer of clay or rock which prevents escape that way, and the prevalence of cloudy days and moist winds prevent much loss of water by evaporation. So, sooner or later, most of the rain that fell in that storm becomes available for the farmers between its falling-place and the sea.

Now trace what happens to rain falling near Bathurst, N.S.W. About the same amount falls each year, but much less becomes useful. The soil is drier and looser, and lets it through: the real Macquarie River flows, not along the channel you see, but fifty or sixty feet underground. Lower down its course it can sink hundreds of feet through the loose unretaining soil. And what does flow off along the surface, or near it, is soon evaporated by the dry winds and hot suns that are sure to follow a rain-storm.

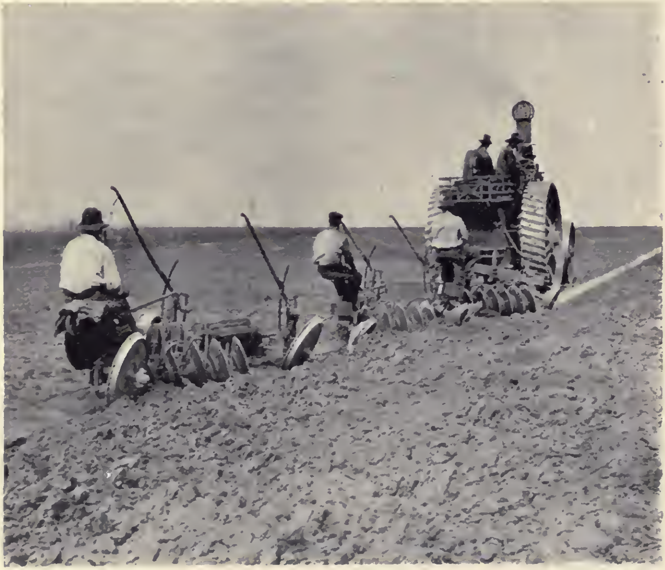
Further out, in the western plains, this double loss of water is extremely serious. It has been officially calculated that between 1895 and 1903, excluding the year 1902, every square mile of Murray River watershed discharged 12 times more rainfall than a similar area of Darling watershed, the rainfall discharged by the Darling being only about .7 per cent. The rest has been evaporated or soaked deep into the ground. In England about 33 per cent. of the rainfall is discharged by the rivers.

So it is not merely the irregularity of the rainfall that counts—other countries are as badly off in that respect—but the combination of spasmodic rains, drying winds, and loose soil to a great depth. If we had to depend on Nature's arrangements only, these three factors would make the greater part of New South Wales useless for agriculture and incapable of supporting a large population. Thus it was at its discovery. Only in the hills and along some river-banks was animal life abundant: and the aborigines were split up into small isolated tribes, each hunting for its food through a great area of country, and none increasing its numbers to any visible extent.

The steady growth, therefore, and prosperity of the State was impossible without some sort of artificial water-supply. This takes two forms—preserving the surface waters, and reclaiming those that have sunk to great depths. Also, whether they are preserved or reclaimed, they must, for agricultural purposes, be distributed to the crops: animals can come to drink them just as to natural streams or lakes.

The story of the State's water-supply thus falls into four divisions—rainfall and rivers, tanks and dams, artesian wells, and irrigation. A fifth, perhaps, may be made to deal with flood-prevention: for, while in the valleys and plains the rain is apt to soak away before it can be utilized, on the ranges it meets with rock that it cannot soak into, and goes roaring down a hundred steep gullies to one almost flat alluvial river-channel, so little above the sea-level that its outflow is blocked twice a day by the tides; whereupon the downrush is thrust over the low banks on to the farmlands that border them, and flocks, crops, and often even the soil itself is swept away in the flood. This is the one drawback to the valley of the lower Hunter, which would otherwise be the State's most valuable region: and it is as necessary in the coastal strip to provide against damage by flood as in the western lands to guard against drought.

The natural rainfall in New South Wales varies from 40 to 60 inches on the coast where much rain comes in from the sea, to 8 to 9 inches in the extreme west: the decrease along an east-to-west line is (with two notable exceptions, for which see p. 203) remarkably regular. The only trouble is that it sometimes comes inopportunely. In the Wagga district, for instance, the year may be ending prosperously on a 21-inch rainfall: suddenly there is an extra fall of two inches, just as harvest begins, and the farmers lose all the profit they were hoping for. And from one end of the State to the other the rainfall is a good deal heavier in the first six months of the year than in the last—which serves well for the fall-ploughing and the growth of winter grass, but leaves the spring growth of grass and grain and fruit inadequately supplied. (Fig. 85.) As for the rivers, which in many countries are natural irrigation channels fed from huge natural reservoirs (the central snowfields of Europe and Asia, the rain-receiving hillsides of much of the Atlantic coastline), in New South Wales, as has been said already, they have for the most part neither reservoirs to feed them nor channels sound enough to hold the water that runs down them. The few exceptions—the Snowy River, and the upper courses of the



Tourist Bureau, N.S.W.

Fig. 85. Disc Ploughing with Traction Engine, Goonoo-Goonoo, Tamworth District, N.S.W.

Murray and Murrumbidgee—rise in or near the plateau of Kosciusko, on which snow lies for the greater part of the year.

So reservoirs must be made. Every station, of course, has its tanks and dams; and the Government has made more than 300 along the stock-routes, to give water for travelling stock; and some private owners have weirs across the smaller streams running through their property, which divert the flood-waters into reservoirs alongside. (Fig. 86.) Notably at North Yanco station, in the Riverina, a creek running parallel to the Murrumbidgee has been dammed and diverted for irrigation purposes with great success. Also twenty-three of the larger country towns are supplied with

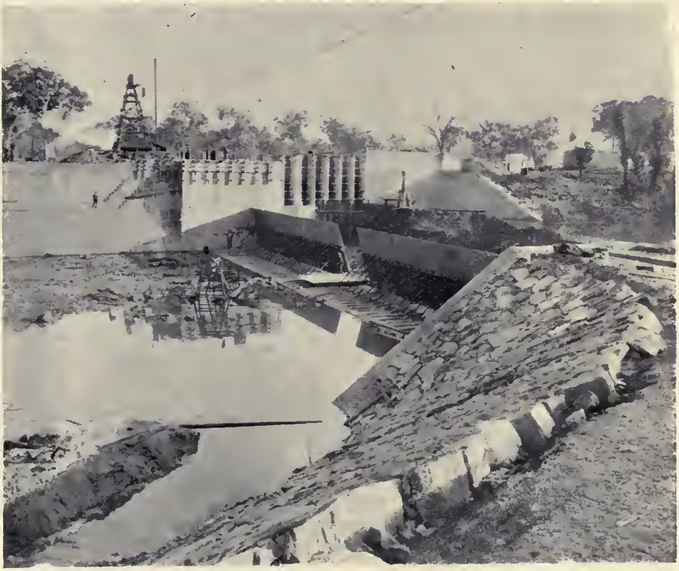
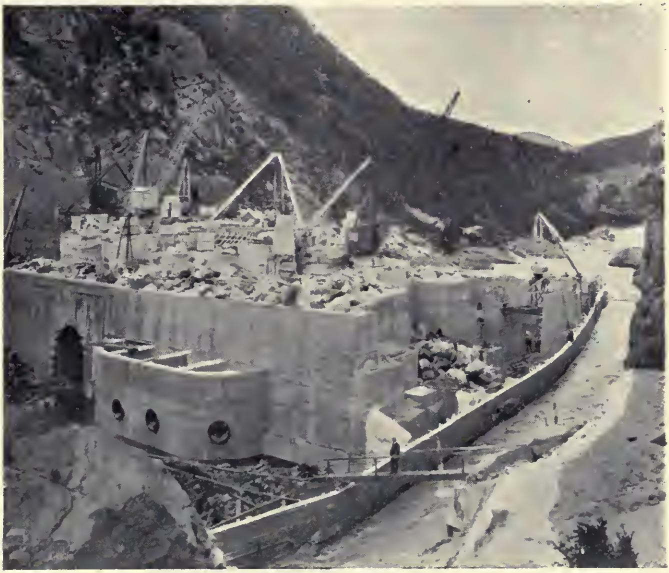


Fig. 86. Canal Regulator and Entrance to Narrandera Irrigation Canal. Murrumbidgee River.

water from dams across the best-watered creeks in their neighbourhood: and Sydney and its suburbs draw their supply from a series of dams on the Nepean and its tributaries, the newest and biggest of which holds 21,000 million gallons—thus, with the older dams, securing to Sydney about three years' supply without replenishing.

Reservoirs for irrigation water have been talked about for many years. In the neighbouring State of Victoria much has been done, and New South Wales is at last beginning to follow that example. The gorge under Burrin-juck Mountain, on the Upper Murrumbidgee, is being closed with a great dam which will throw back the water for forty miles along the river's course. (Fig. 87.) Behind this the flood-waters will be imprisoned as they come down, and gradually let out during the drier months, so as to keep the flow down the lower river fairly regular from year's end to year's end. There is talk of a similar piece of work on the Upper Murray, and it is planned to dam the upper Lachlan some way above Cowra, and the Macquarie below Bathurst, forming storage reservoirs in the rocky gullies they traverse. Schemes have also been proposed for placing weirs on the Darling, Lachlan, and other rivers of the plain; but in that loose soil the rush of flood-water, if barred at one place, may easily break through and form a new channel further up, which would mean costly repairs or even more costly preventive barricades. A more feasible scheme, which may be soon in operation, is that of damming the Warragamba, a tributary of the Hawkesbury, in one of its gorges, and distributing the stored water among the farms between Parramatta and the Nepean.

Although the western rivers, directly they issue from the foothills of the main range, begin to lose water very rapidly, a great part of it goes where it can be recovered. If on the map of New South Wales you draw a line through Wellington, Gunnedah, and Warialda, and another through Nevertire and Moree. you will enclose a strip of country all over which the rocks just beneath the surface are extremely porous. and drink up all the water they possibly can. As they slant rapidly downwards to the west between two layers of harder rock through which water cannot pass, the water, too. soaks down to west and north till it is from 1000 to 3000 feet below the surface. Thus under a large portion of northern New South Wales (bounded approximately. by the strip just mentioned. the Bogan



Works Department. N.S.W.

Fig. 87. Burrin-juck Dam across Murrumbidgee River.

and Darling Rivers, and latitude 31°) lies a huge sponge, sandwiched in between impervious rocks above and below, constantly supplied with more water from the "intake beds" of the strip, and only able to get rid of it by very slow soakage through hundreds of miles of rocky sponge that spread northwards to the Gulf of Carpentaria. The geological aspect of this subterranean "sponge"—which is, of course, the Artesian basin—is considered in Chapter XII., but various economic features require mention.

Most of the artesian bores were originally sunk to get water for stock, and all but a few are still used only for that purpose. Between the Castlereagh and the Dumaresq, in the artesian district, lying within this State fifty-five "trust districts" have been formed to distribute bore water over pastoral country. More than 2,800 miles of channel have been constructed, which can water more than 4,500,000 acres of country sufficiently for stock-raising purposes.

But on fertile soil there is much better use for any water that can be got. And the real value of all these devices for storing or recovering the State's rainfall lies, as we have lately begun to understand, in the weapon they have placed in the farmer's hands. At the beginning of this chapter we said that a regular supply of water would make the difference between rich crops and barren land. Reservoirs like that at Burrin-juck, artesian wells like those at Moree and Coonamble (which discharge one and two million gallons a day respectively), give this regular supply, and will in the favoured districts remove the agriculturist's last excuse for poor farming. The Burrin-juck reservoir (Fig. 88), indeed, was devised expressly to supply water to irrigation areas about three hundred miles below the dam: it will travel down the river as far as Narrandera, and then

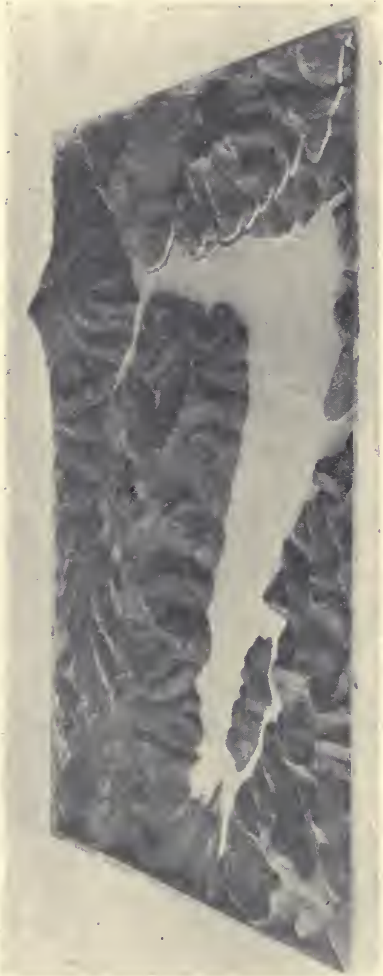


Fig. 88. Burrin-juck Reservoir when full. The Dam is at the right hand top corner.

Works Depart., N.S.W.

by a canal running north-west to the Merool Creek, where about 360,000 acres can be well watered and a considerably larger area supplied with drinking-water for stock. (Fig. 89.) Later on another canal will be run towards Hay parallel with the railway line, and a third will supply an irrigation area south of the Murrumbidgee. On irrigated land now held by private owners a water-rate will be levied: but more than half the area is to be resumed by the State and resold in plots of 100 acres or less to settlers who are prepared to grow fruit, grain and root crops, or even tobacco and cotton. The Upper Murray reservoir will in the same way command nearly a million acres of farmland and half a million acres of pastoral country.

Artesian irrigation has been carried on mainly at the Moree and Pera experimental farms (the latter seven miles from Bourke). Here all sorts of vegetables and fodder, and fruits such as peaches, prunes, figs, melons, oranges, and grapes are being grown with great success (at the Moree bore cotton is found to be hardy and prolific). The bore water at these experimental stations contains about 50 grains of salts in a gallon. This is of course deposited in the soil, but in such small quantities appears to be harmless. In a considerable number of cases the impurities increase to twice this amount. The chief reason why farms which can be supplied with suitable water are not spread over the whole artesian district is its distance from the central market and the sea coast. As the intervening lands are occupied, and a local market comes into existence, the great plain north of the railway line from

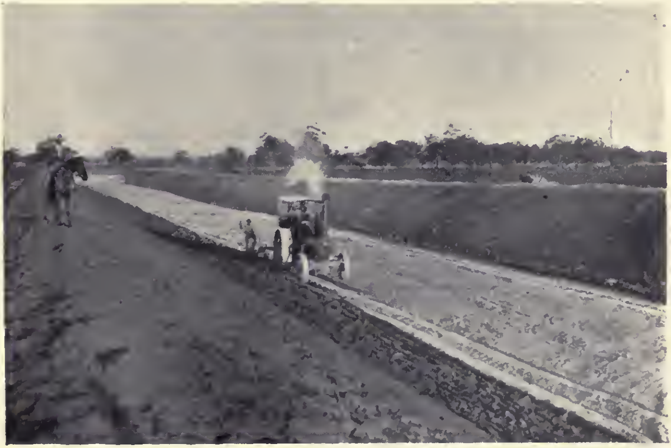

Works Dept., N.S.W.

Fig 89. Making Canal, Northern Murrumbidgee Irrigation Scheme.

Dubbo towards Bourke may yet become a land of farms and orchards. South-west of that line, to within fifty miles or so of the Junee-Hay line, the country is likely to remain in the pastoralists' hands except for strips of irrigated land along one or two of the bigger streams. Thence south to the Victorian border more farms will cover the country. And all this metamorphosis of what we described as being now purely pastoral plain-country will be wrought by the simple process of storing and distributing supplies of water which have been at our disposal ever since the country was first occupied.

One use to which water has not yet been put in New South Wales is to drive machinery. Other countries put both their steep and rapid rivers and their artesian wells to use in this way: but New South Wales has been so well supplied with fuel, both coal and timber, that no efforts have yet been made to utilize the immense water-power available along its eastern watershed. Schemes have been projected, and are being revived, for transmitting electric power to Sydney from turbine stations in the Blue Mountain gorges. And it has been shown that, by means of simple machinery such as is used all over Texas, U.S.A., many artesian flowing wells could be made to yield just a few horsepower, enough for driving farm engines and small factory motors. The State's water-supply, other than artesian, when we have once learnt to use it, will become an important factor in its manufacturing, as well as in its agricultural, industries.

CHAPTER XVII.—COAL AND METAL MINING IN NEW SOUTH WALES.

(T. G. TAYLOR, B.A., B.E., B.Sc.)

If a map of New South Wales be coloured so as to indicate in a general way the distribution of valuable **minerals**, it will be noticed that there are four or five well marked mineral provinces.

But the State may be subdivided on another plan, according to the **relative ages** of the rocks. Most sedimentary rocks, which have generally been laid down in water, contain relics of the fauna and flora of the times in which they were deposited. These included **fossils** enable the geologist to say which rocks are oldest in a given series. Thus a large area of rocks in the south-west of the State contains fossils closely resembling animals and plants now living. These rocks belong to the **Tertiary**, or third great Geological Age. Some large areas in the north-west plains are characterised by relics of huge reptiles kin to no modern fauna; which, though not numerous, are enough to place this portion of the State in the **Secondary** age. A third well-defined province consists of the productive coal Measures and it belongs to the later **Primary or Palæozoic age,** *i.e.*, to the newer portion of the oldest group of fossil-bearing rocks. The main backbone of the State consists chiefly of older palæozoic rocks whose fossils, corals, sea-lilies, trilobites, etc., show no close relationship with modern animals and are immeasurably older than others mentioned previously. They are penetrated by an extensive series of eruptive rocks like granite and diorite. These rocks are very hard and resist erosion by the weather.

Moreover they have very often baked the fossil-bearing rocks, and made them also more resistant. So that we should expect the high land to be composed of these older rocks.

Comparing the two schemes we have thus outlined, we see that there is a relationship which is more than accidental. The following table shows **very broadly** the correspondences :—

District	Geological Age	Minerals
Northern and Western } Plains Riverina	Tertiary and Secondary	*Absence* of gold, silver, copper, tin, lead. *Absence* of coal. Presence of opal.
Coal bearing sediments of Newcastle, Lithgow and Bulli	Late Palæozoic (Permo-carboniferous)	Largest deposit of coal in Australia. Some iron ore occurs on the borders of the coal basin. Other minerals unimportant.
a. Barrier and Grey Ranges	Early Palæozoic	Silver-lead ;
b. Cobar-Kosciusko		Copper, gold ;
c. New England and Macleay		Tin, gems and gold.

If a giant knife were to cut through the rocks of the earth's crust from Broken Hill to the Pacific along the parallel 32½ degrees, and the southern portion were removed, we should see a **geological section** of the rocks somewhat as represented in Fig. 6.

The two newer deposits of rocks are shown lying in basins formed of much older rocks. The western plains are very much newer than the coal measures, while both have obviously been deposited on top of the early palæozoic sediments long after the latter were consolidated into rock, and had been folded crumpled and eroded throughout long eras of geological time. It will be noticed that the metalliferous portions of the State are those where the old palæozoic rocks project through the later deposits. as at the Barrier Ranges, the Main Divide. and (on parallel 32½) in the Gloucester-Stroud district.

Discussing in greater detail the map (Fig. 90) we notice two well defined areas. **First,** the comparatively late deposits occupying the Murray-Darling Basin in its flatter "plain" portion. This area is somewhat dumb-bell shaped. the narrow portion lying between Broken Hill and Cobar. and widening north and south of this. This is essentially **not** a mining district. **Second,** a large area of coal measures enclosed within a line extending from Ulladulla to Gunnedah and thence to Port Stephens. Under the major portion of the eastern half of this latter area, valuable beds of coal occur. It is improbable that much **metalliferous** mining will be carried on in this section, since the beds containing the coal do not seem to have been permeated by the heated mineral-bearing solutions whose cooling gave rise to the various metalliferous veins worked in older portions of the earth's surface.

It is a general rule that the older formations have suffered greater folding. compression and cracking than more recently formed rocks. Accordingly they allow the more ready passage of hot solutions which have dissolved metals probably at a considerable depth below the present surface of the earth. The mere fact that the rocks are very ancient implies a long period for the formation of such ore deposits which would be wanting in Post-Palæozoic, or geologically new. areas.

The remaining areas are respectively the Broken Hill region, that of New England, and the great Gold-Copper area extending roughly from Cobar to Cape Howe. In

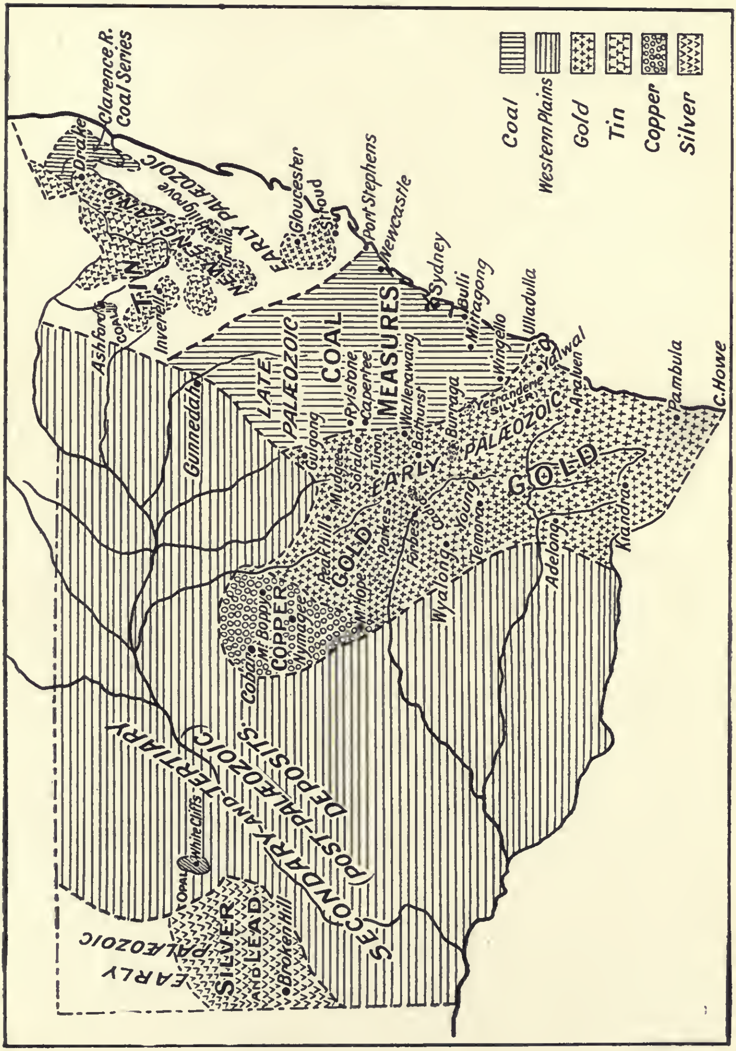
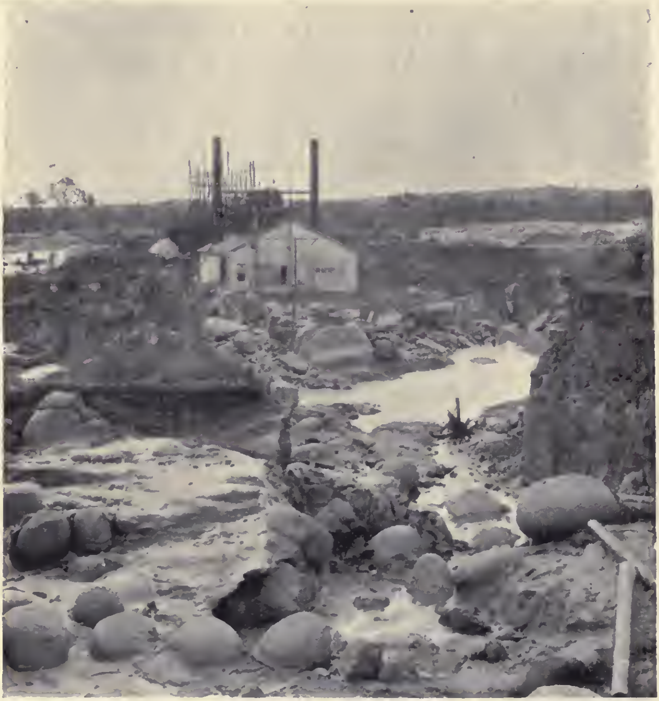


Fig. 90. Mining Map.

all these districts we see the old foundation sediments emerging from the later deposits. Thus at **Broken Hill** the silver-lead ore is contained in a highly altered and crumpled set of rocks possibly representing the oldest



Tourist Bureau, N.S.W.

Fig. 91. Tin Dredging at Copes Creek, Jingha, N.S.W.

in Australia. These have been folded so as to leave spaces in which hot solutions have deposited valuable minerals in huge masses. The **New England** district consists largely of slates and hard shales through which burst masses of the eruptive rock, granite. Hence arose probably the tin deposits, since tin compounds have accompanied granite intrusions in many parts of the world. (Fig. 91.) Gold and copper occur also in the district. but not to such an extent as in the area next under consideration.

All that huge extent of country reaching from **Cobar to Cape Howe** consists mainly of very ancient slates and limestones, which have been folded, cracked, and intruded by many different kinds of eruptive rock such as diorite, granite, porphyry, etc. It is a well-established fact that the junction of a rock such as limestone with an eruptive rock like diorite, furnishes favourable conditions for the deposition of ore-bodies, probably owing to a chemical interaction between the metal-bearing solution and the two diverse rock masses.

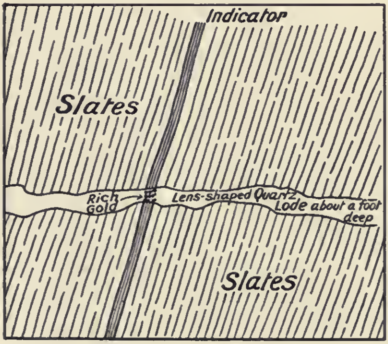
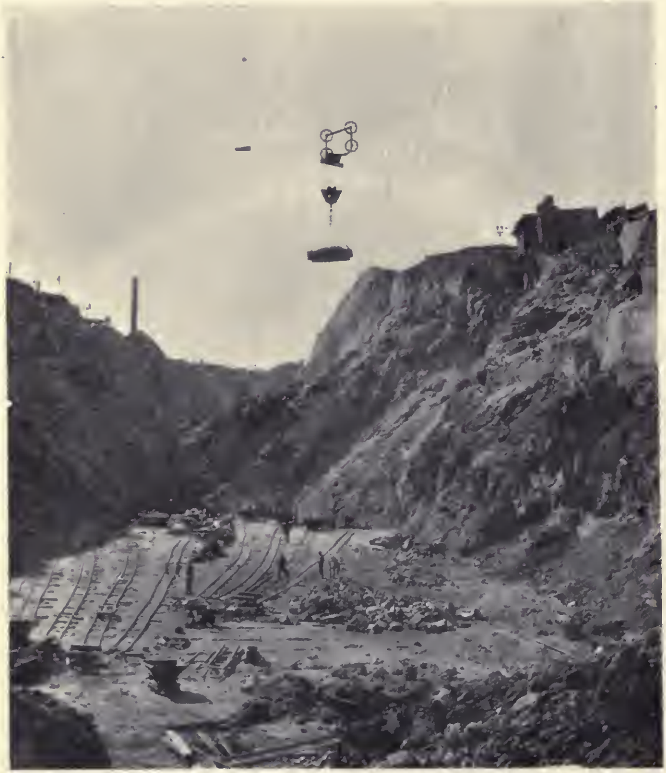


Fig. 92. Ballarat "Indicator."

Metal Mining.—The mining industry is of sufficient importance to warrant a short account of a typical **metalliferous reef** and the method of working it. In many cases, as at Gundagai, a fissure in the earth's surface has formed the channel for heated waters from lower regions of the crust. These liquids carry quartz and various valuable metallic compounds in solution. On reaching cooler masses of rock the quartz is deposited forming a "reef" and containing metal, gold perhaps, scattered through it. Often a specially rich "bonanza" of gold is determined by the selective chemical action of a definite wall rock on the solutions. Some veins are rich when worked in granite, but barren when intersecting limestone. Very often the presence of a "dyke" or intruded body of eruptive rock such as "diorite," cutting across the main lode has determined a rich portion of the ore body. At Ballarat a thin band of carbonaceous shale "indicates" where rich gold may be expected (see Fig. 92) in the lode which cuts across



Tourist Bureau.

Fig. 93. "Open Cut" Proprietory Mine, Broken Hill.

the former, the shale band having caused an exceptional deposition of gold from the heated solutions in the vicinity.

When the reef has been exposed to the action of the weather and surface waters for long periods, **secondary alterations** of great importance are liable to occur. Thus at Broken Hill, the unaltered ore below the level where air and water readily affect the lode, consists of a mixture of minerals of lead, zinc and silver combined with sulphur, known as **sulphides**. At the surface the oxygen of the air acts on these three kinds of minerals unequally. The silver remains practically insoluble, and hence is not removed in solution. The zinc compound becomes soluble in water rather readily and is carried down to lower levels of the crust as far as the surface-water will reach. The lead is acted on to a somewhat lesser degree and is thus separated naturally from the zinc, which, until lately, has been more of a curse than a blessing to the metallurgist. This fact tends to explain changes of ore in depth frequently encountered in opening up a mine. An old mining fallacy that "ores improve with depth" is worthy of note in connection with our numerous copper and gold deposits. In many cases what was originally a lode of copper sulphide containing a little gold of **uniform** low value throughout, has become altered almost beyond recognition by subsequent natural solution and deposition. In some of the Cobar mines the ore at the surface consists of a payable gold body. Then lower comes a zone of copper ore fairly rich in gold. Possibly below are rich "bonanzas" of an isolated

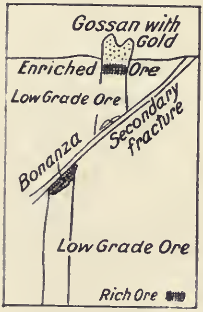


Fig. 94. Bonanza.
(W. H. Weed.)

nature, and finally a body of very low grade ore which certainly gets no richer as the shaft sinks further into the earth's crust.

The foregoing diagram, (Fig. 94), due to W. H. Weed, explains such occurrences. The copper has been dissolved out of the upper capping, or "gossan," of ore and has left the gold contents in a free and fairly pure condition. The soluble copper salts have helped to enrich the load below the gossan. Below this zone we have the original low grade ore, which may become extremely rich if intersected by later cracks and fractures by which surface solutions have been able to act on the low grade ore. Apart from these latter bonanzas, since the natural concentration, solution and deposition due to surface waters cannot act below a certain zone, the chances are rather in favour of the ore losing value with depth.

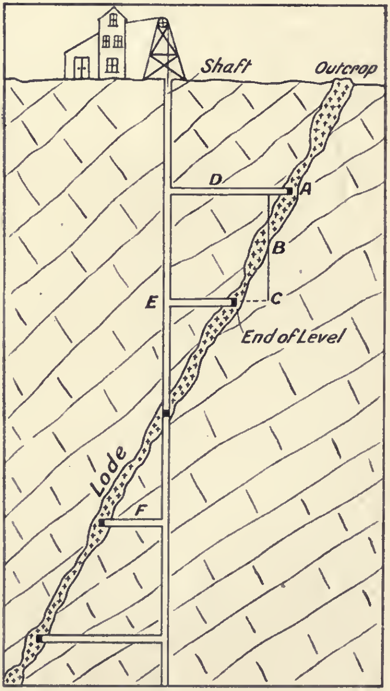


Fig. 95. Gold Mine Workings.
Vertical cross section of a metalliferous mine.

In **working a gold mine**, a shaft is usually sunk near the "outcrop" of the lode, on the side to which the lode slopes, should the lode not be vertical, which is rarely the case. Then "cross-cuts" D., E., F., see Fig. 95, are put in to connect the shaft with the lode at regular intervals of perhaps 100 feet apart in depth. Where each cross-cut intersects the lode, a "level" is driven along the course of the lode as at A, C, etc., where the levels are seen in section. When a level has been driven a convenient distance along the lode, the ore above the level is broken away, or "**stoped**" as it is called, loaded into trucks and "**trucked**" to the shaft through which it is hauled to the surface. After a time the level is timbered over and the cavity above filled with waste material or "**mullock**" up to within a short distance of the ore still to be mined. Another strip of ore is then broken away and thrown down a "pass," built in the mullock, to the trucks in the level below. This is repeated until the level above is reached, when that particular part of the lode is said to be "**stoped out.**"

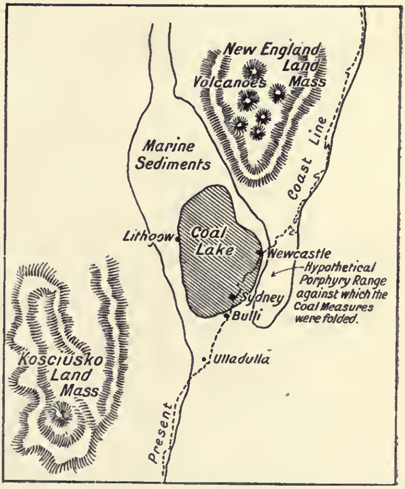


Fig. 96. Coal Measure Gulf.
N.B.—In the Coal Age the coast line was undoubtedly far to the east of its present position.

Coal Mining.—In late Palæzoic times, possibly 5-10 million years ago, a large gulf extended north from Ulladella to the Queensland border and probably further north. See (Fig. 96). The rivers of that age poured in sand, gravel, clay, etc., and spread layers of material over the bottom of this shallow gulf. The whole area was undergoing gradual subsidence. After several thousand feet of deposit had gradually accumulated the gulf became land-locked and freshwater conditions obtained for some time. Huge ferns flourished in the brackish water, forming peaty bogs and gradually building up deposits of organic matter hundreds of feet thick. Further periods of marine deposition covered over the plant remains under four or five thousand feet of sand and shales.

A similar alternation of sediments and organic matter succeeded, accompanied by continued slow subsidence, so that probably, though some 14,000 feet of sediment were deposited, the gulf or lake was never exceptionally deep. The combined pressure and chemical alteration converted the fossil plants into coal, of course accompanied by a vast diminution of bulk; later slow elevation brought the coal thus formed again towards the surface.

Since the elevation of the **coal measures**, as the sediments accompanying the coal are termed, above sea level, a great **folding** has taken place in this area, which has been described in other chapters (see p. 37), which folding has depressed the eastern portion of the coal basin relatively to the western. The nett result is that the coal seam, representing the latest of the extremely ancient fern swamps, is some 3,000 feet below Sydney, whence the seam gradually rises in all directions and emerges at the surface, or "outcrop," at Newcastle, Lithgow and Bulli. (Fig. 97.) In fact we can picture this chief seam of coal as a gigantic "**saucer**" about six feet thick and about 100 miles in diameter, containing later deposits (Triassic), some 3,000 feet thick in the middle of the "saucer" but gradually thinning out towards the edges. (See Fig. 2.) For instance, at Helensburgh, on the South Coast line, about 20 miles from the "rim of the saucer," the coal is found 1,100 feet from the surface. At Katoomba to the west, the coal outcrops in the deep gullies, while at Lithgow it appears at the general surface level of the country, this being the western rim of the saucer.

Kerosene shale is also mined in the coal measures of this region. (Fig. 97.)

A coal mine is worked on very different principles from a gold mine. In the latter case the ore won is

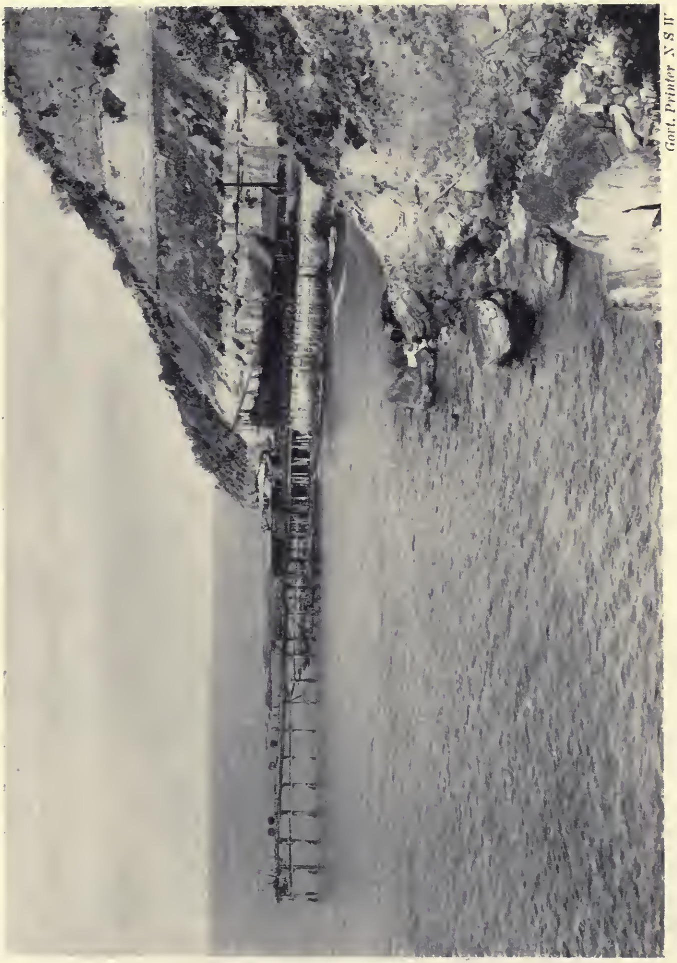


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Fig. 97. Coal Cliff Colliery on Bulli Coal Seam, South Coast District, N.S.W.

worth from say 20s. to £8 or more a ton, and usually varies rapidly (with the richness of the reef) above and below these limits, necessitating careful choice of material for later treatment. In the former case we may have a six foot seam of coal extending uniformly in a fairly level layer for many miles. The product is

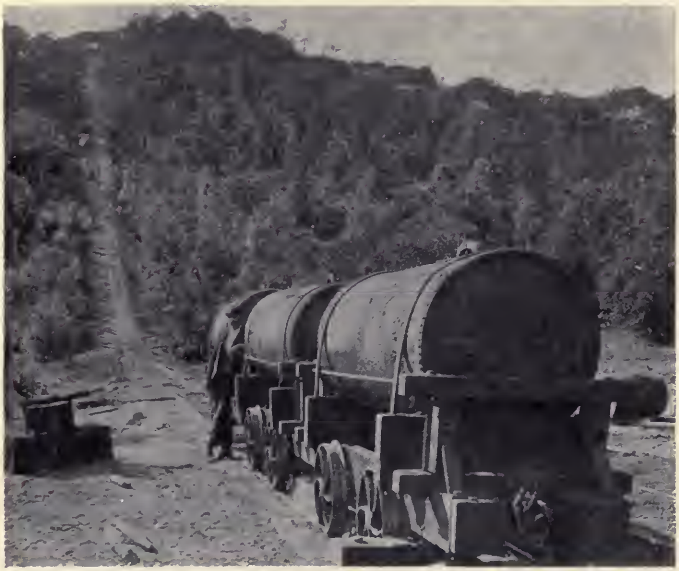

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Fig. 98. Kerosene Oil Tanks of Commonwealth Oil Corporation.

worth from 5s. to 10s. a ton and huge quantities are worked. The mining of coal is further complicated by questions of **ventilation** and **transport**, owing in a large measure to the many miles of workings into which a coal mine develops. Where the mine is worked by shafts two are necessary, one being used for hauling and to pass air into the mine, hence "the down cast,"

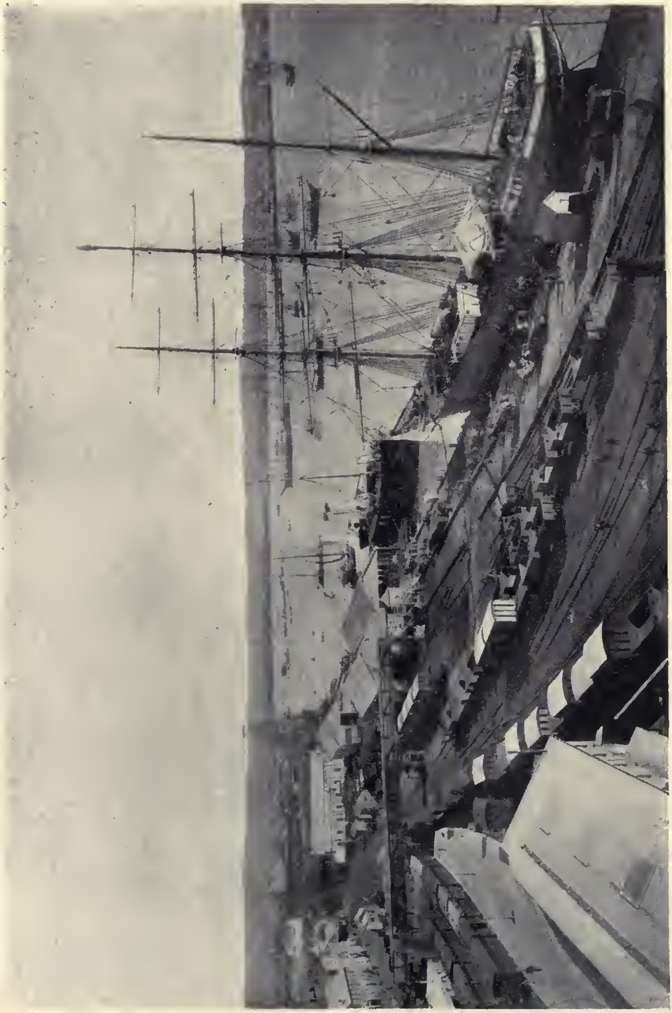

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Fig. 99. Newcastle and Harbour: the chief coal shipping port of New South Wales.

whilst the other shaft, "the up cast," acts as an outlet for foul air.

In several of the Newcastle mines, coal-cutting machines are used for under-cutting the coal. One pattern consists of a circular saw, the teeth shaped like chisels, which is hauled along a tramway close to the face of the coal. The saw rotates steadily and under-cuts the coal just above the floor. By this method much less coal is wasted as "slack" and the work is done rapidly and cheaply. (Fig. 99.)

There are seams of coal in other parts of New South Wales, notably in the Clarence River district, but these seams contain too much "ash" to be of anything but local value. They are interesting as being of considerably later age than the seams near Sydney, and become of much better quality to the north where they outcrop in South Queensland.

A more promising seam occurs at Ashford, near Inverell, but has not yet been fully opened up.

In concluding this section a list of the chief mining fields of the State will be of interest. The localities are inserted on the map (Fig. 90). The figures are from the official Year Book, and refer to 1908.

Gold.—	Cobar district	82,648 ozs.
	Forbes district	33,205 ,,
	Southern (Araluen, &c.)	27,549 ,,
	Mudgee district	21,987 ,,
	Adelong ,,	18,379 ,,
	Bathurst ,,	17,103 ,,
	Uralla ,,	15,849 ,,
	Turon ,,	18,379 ,,
Silver-Lead.—	Broken Hill	£3,215,325
	Yerranderie (Burragorang)	£114,029

Copper.—Cobar	£347,429
Mount Hope Cadia Burraga Nymagee	totalling £155,383.
Tin.—Inverell	£117,600
Iron.—Cadia Wingello Mittagong Wallerawang Rylstone	not largely worked.

CHAPTER XVIII.—THE INFLUENCE OF PHYSICAL FACTORS ON SETTLEMENT.

(T. G. TAYLOR, B.A., B.E., B.Sc.)

In New South Wales the industries in which her people are engaged may be divided into two main classes, agriculture (including the pastoral industry) and mining; and a third dependent on these, the manufacture and transport of raw products obtained by those engaged in the preceding. Each of these three divisions is controlled mainly by one of three chief conditions of environment. Thus it may be broadly stated that agriculture, mining and transport are closely linked respectively with necessary climatological, geological and geographical surroundings. These **physical factors** to a large extent control the industries of the State.

In most of the older civilisations, towns and industries have arisen in localities determined to a large extent by their suitability for defence against hostile tribes or natives. In Australia, with the possible exception of Fort Bourke, such has never been the case, and all settlement has been decided from an economic point of view.

GEOGRAPHICAL.

It is scarcely necessary to emphasise the fact that the geographical distribution of mountain and plain exercises a profound influence on the life and industries of the people. In a new country like our State, population follows the railways as a rule; the latter follow **natural** lines of traffic. Thus we have the old main roads following mountain ridges, and usually crossing from one river basin to another by natural gaps in the watershed. The long narrow plateau of Mt. Victoria, due to the carving action of the Cox and Grose Rivers, has determined the route of the main Western Railway. The Southern Line reaches the Riverina district by way of the similar ridge near Tallong, and thence *viâ* the comparatively low area between the Cullarin and Gourock Ranges, on which Goulburn is situated. The position of the Northern Line with its belt of population has been determined by the Murrurundi gap in the Liverpool Range.

On the other hand the geographical conformation of our coast has undoubtedly retarded industrial progress in certain respects. The want of good harbours militates greatly against a flourishing coastal trade. The presence of the numerous mountain spurs, often at right angles to the coast, has chopped up the latter into a succession of headland and river mouth, which has for so long prevented the construction of a coast railway.

Hence we see that the situation of the ranges of the Main Divide close to our coast has given rise to numerous rivers which, with the exception perhaps of the Hunter and Clarence, have not formed extensive flat coastal areas suitable for intercommunication of the above type. If the coast had undergone recent elevation, instead of a preponderating subsidence, a suitable plain of marine erosion might have arisen, but under present conditions New South Wales will continue to be somewhat handicapped in this respect.

The positions of many settlements growing into important towns have been decided by "critical points" along the river valleys. The **mouth** of a river is one such point and has led to the foundation of most of our coastal towns, such as Moruya and Ballina. Often a position some little distance from the mouth is chosen, where the ground is more elevated and healthier, and where usually the river bed is better defined, such as Nowra. The **head of navigation,** which marks the point of least possible land carriage of native produce, is a common site for a town. Thus Clarencetown marks the farthest point to which small cargo steamers can ascend the Williams River. Morpeth and Paterson are similar towns on the Hunter and Paterson Rivers respectively. Grafton marks the limit for large ocean steamers, and hence is a suitable collecting base for the sugar crops of the district.

Climatological.

Where settlement is based on strictly economic grounds, climate is a most influential factor, except where valuable ore deposits occur. In the latter case, as at Broken Hill and Coolgardie, cities are wont to spring up in utter defiance of all climatological considerations.

It may be stated that the limit of profitable wheat growing is roughly bounded by the 20 inch isohyetal (line of equal rainfall). As demonstrated in a former chapter the distribution of rain depends largely on the configuration of the earth's surface. Since the general direction of the rain zones is parallel to the coast, we are naturally prepared for a similar arrangement in agricultural distribution.

As shown in the sketch map (Fig. 100), there are three well defined zones of agriculture in New South Wales.

Zone I.—Along the coast, to the east of the Divide, is a long belt of agricultural country, ranging from an average temperature of 69° F. and rainfall approaching 70 inches, as obtains in the north, to an average temperature of 60° F. with a rainfall down to 30 inches in the Bega district. This climate is suitable for cattle, and the rainfall is sufficient for **dairy herds**, so that creameries and allied trades are distributed all along our coast.

Such industries as these are well suited for small isolated settlements with fairly **easy access** to the metropolis, a condition fulfilled by the coastal steamers and South Coast railway.

Though dairy produce ranges from north to south, yet other industries are not able to flourish over such a range of climate. Maize and lucerne thrive well in the central portions of this coastal strip, but sugar is confined to the moister, hotter regions of the North Coast rivers. The chief timber areas of the State also occur in the thick scrubs of this northern and best watered coastal zone.

Two circumstances introduce anomalous factors into the above simple coastal distribution of industries. Firstly, the presence of the great **Coal Basin** of New South Wales, and secondly, the presence of a huge **metropolis** such as Sydney, towards the centre of the zone. Dealing with the coal basin elsewhere, where the other mining areas are considered, the effect of a large city on its environment may be investigated.

Obviously all areas within fifty miles of Sydney are exceptionally situated as regards transport of produce to such a centre of consumption. Hence one would anticipate that certain industries having to do with perishable material would spring up in this extra-urban district. A case in point is **fruit-growing**. This industry is carried on to a very considerable extent in the districts to the north-west of Sydney, from Ryde to Windsor, and south to Campbelltown. The soil is comparatively poor, and not to be compared with that of the Northern Rivers, but transport difficulties from the latter are too great at present. It may be noted that the fruit-growing areas are confined to a great extent to the Wianamatta-Shale soils, the sandy soil from the Hawkesbury Sandstone being too poor, in its original weathered state, to support fruit-growing.

The rich belt of maize and lucerne country, between Penrith and Windsor, owes its productiveness to the flood silt and river mud carried down by the Nepean River.

The presence of a range of mountains some 3-4,000 feet high within easy reach of Sydney, has given rise to many **residential towns** where the Southern and Western railways cross that range to reach the western portions of the State. Thus Moss Vale and Mount Victoria have a mean summer temperature four or five degrees lower than that of Sydney, 70.7 F.

In this spreading of residences along the main trunk lines we see an example of the "star shaped outline" which is a characteristic of the modern city, and so different from the compact outline of mediæval cities, still common enough in Europe. There is little doubt that the tendency of the next century will be one of decentralisation, leading probably to the clustering of suburbs all along the railways within 100 miles of the metropolis. With electric traction such a distance will probably be traversed comfortably in an hour. Apart from such occupation the huge tracts of Hawkesbury sandstone, which constitute the major portion of the Blue Mountains, seem doomed to a more or less unproductive future. Of especial interest therefore, are the highly fertile patches of black soil to the north-east of Blackheath. These productive areas form the capping of such high hills as Mt. Tomah, Mt. Wilson and Mt. Irvine. They illustrate the influence of geological environment, and in fact the rich soil is merely an **ancient volcanic lava** which has crumbled into its present condition. The fertility of the district between Bundanoon and Robertson (near Moss Vale), one of the richest agricultural and dairying districts in New South Wales, is due to the same cause.

Zone II.—The next area may be defined roughly as the **Wheat Belt** of New South Wales. Its boundary on the west corresponds with the 20 inch isohyetal, near Victoria, and the 25 inch isohyetal in the north, but a portion of this rain must fall during certain necessary periods in spring to ensure a satisfactory crop. The eastern boundary is ill defined, and probably wheat could be grown in most of the eastern portion of New South Wales, except where the rainfall is very heavy. The western slopes of the Divide are however the districts given up mainly to wheat since it is found that the moister conditions of the Littoral Province are favourable to smut and other diseases.

Although 20 inches rainfall is spoken of as the western boundary of the wheat belt, it is highly probable that special methods of cultivation,* and special

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***e.g.*, "Dry-farming." etc.

varieties of wheat will extend this boundary quite to the 12 inch isohyet in the very near future.

The wheat belt coincides somewhat with the great gold-copper Mining Province, but the influence of the latter on the population will be briefly discussed after a consideration of the third climatological region.

Zone III.—In the third climatological zone, lying to the west of the 20 inch isohyetal, we have an area too dry as a rule for agriculture, unless helped by irrigation and "dry-farming"; but eminently suited for pastoral pursuits; and the character of settlement varies again. Instead of townships of some three or four hundred inhabitants established every twenty miles, as is the case in the settled portions of the wheat belt, we see in the third zone isolated "**Stations**" whose distance apart varies directly as their distance from Sydney. Since the number of sheep or cattle carried per acre depends on the rainfall, as we go farther west the holdings need to be larger and larger to yield adequate profits. With a rainfall some ten inches greater than at present the western plains would rival the wheat belts of Central United States of America and Canada. where the soil conditions are somewhat similar.

A few words as to the origin of these immense **Western Plains** will not be out of place. Originally the various tributaries of the Murray entered a large estuary (extending nearly to Wilcannia) by separate mouths. These rivers during flood times spread a fertile flood-silt over the surrounding country derived from the weathered rocks of the Great Divide and from the "Desert Sandstones" of the interior. The former supply consisted in many cases of disintegrated basalt, which forms the "Black Soil" plains of the northern portion of the Plains Division; the latter possibly gave rise to the reddish soil, containing a fair amount of iron, which though not so fertile as the preceding is yet quite capable of supporting an agricultural population provided that the necessary moisture be present.

Geological.

As stated in a previous chapter, mining conditions vary with the type of material won. The two chief classes of mining, for metals and for coal, make for two different classes of population.

Our **coal deposits** occur as beds or flat layers extending over huge well-defined areas of country. Their extent and value are to a certain degree known, and warrant a large outlay of capital, thus ensuring constant employment for many years. As a result a coal mining area is characterised by a series of **thickly populated towns**, each clustering round a set of mines, and traversed by a more or less complete network of railways private or public. Shipping ports are developed, as at Newcastle and Port Kembla, at enormous cost. Schools and shops, factories and farms spring up: all dependent on the mining population and ultimately on the mines for their origin and support.

It is safe to predict a much greater population for the **Newcastle district** than obtains at present. The marvellous increase in the prosperity of the Cessnock-Maitland coalfield since the opening of the mines during the last few years, will probably be paralleled by a similar development along the shores of Lake Macquarie. Indeed Broken Bay may yet become a coal port, as the coal undoubtedly here extends below the surface at a somewhat less depth than that worked at Balmain by shafts nearly 3,000 feet deep.*

The **Western Coalfield** at Lithgow has led to the construction of large smelting works in the neighbourhood. Much of the copper produced from ore raised about Cobar is refined here, while the only iron smelting plant in Australia is situated at Lithgow, largely on account of the coal available. The Federal small arms factory has been established here for the same reason.

The **Southern Coalfield** is handicapped by geographical conditions. There are no suitable ports available, though a large artificial harbour is under construction at Port Kembla. However its proximity to the sea has led to the erection of large coke works whose product is shipped for export to South Australia, Tasmania and elsewhere.

In the remote and picturesque valleys near Capertee, on the Mudgee line, geological conditions have led to the opening up of an extensive industry. Here large horizontal seams of **Kerosene shale** are mined. The shale is heated in closed iron vessels, retorts, and from the resulting products of "dry" distillation originate candles, kerosene, various lubricating oils, and other valuable commodities. As this is one of the largest deposits of such mineral in the world, a large and permanent settlement occupied in the varied industries consequent on the shale mining may be confidently predicted.

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*Windeyer's Hawkesbury Bore has struck coal at a depth of 2,322 feet between the Hawkesbury Railway Bridge and Broken Bay. The seam was 3 feet 3 inches in thickness. *V.* Annual Report, Dep. Mines, N.S.W., 1910, pp. 68-72.—EDITOR.

Leaving coal and allied "bedded" deposits let us notice how the presence of a valuable **metalliferous lode** affects the life conditions of a mining population.

Neglecting for the time such huge and exceptional ore bodies as that of Broken Hill, it may be stated that the average mining township depends for its existence on the value of a reef or lode of varying width, depth and length. As a rule the metallic contents are irregularly distributed in the lode, and the future value of the mine can only be judged in a somewhat haphazard way. This leads necessarily to a much slower mode of development, and on a much less extended scale than in coal mining. Again the material handled is less bulky, while as a rule reefs and lodes are irregularly distributed throughout the earth's crust. This makes for a scattered population consisting of **small townships** of some 500 inhabitants as opposed to coal mining centres with several thousands. As a rule the metalliferous mine is linked to civilisation by **roads** only, the traffic not being sufficient to warrant a railway. The comparative want of population in such a mining settlement reacts upon the inhabitants themselves, who are frequently deprived of advantages usually accessible to larger communities. As such settlement is determined solely by geological conditions, *e.g.*, Broken Hill, the climatological factor not entering into the question, those "non-essentials" which tend to make life happy, such as pleasant surroundings, invigorating climate and sufficient rainfall, are too often conspicuous by their absence.

In the extreme west of New South Wales, a somewhat restricted area of hilly country, containing the Barrier and Grey Ranges, is encountered. Here climatological and geographical considerations alike oppose settlement, yet Broken Hill, the third town of New South Wales, is situated in this district. A population of over 25,000 has collected here, every member of which is dependent on the rich mineral wealth hidden in the extremely ancient rocks of the Barrier Range. It is indeed a notable example of the influence of geological environment, which has given useful work to so many individuals, 250 miles from a port or other large settlement, and which has yielded as much as £3,500,000 in one year, or more than the combined value of the gold and coal won in the State during the same period.

CHAPTER XIX.—INDUSTRIES AND MANUFACTURES.

(A. W. JOSE.)

(NOTE.—The tables given in this chapter *are not to be learnt by heart.* They are merely intended to show in a clear and graphic fashion the stages of industrial development and the comparative values of various industries.)

At the end of Chapter III. the principal industries of New South Wales were incidentally mentioned—wool-growing, wheat-growing, dairying, timber-hewing, fruit-growing: if to these you add mining for coal, gold, silver, copper, and tin, horse-breeding, stock-raising for meat, and a certain amount of wine-making, you will have a fairly complete picture of what the people of the State do with their land. (Fig. 100.) Besides all these, what are called "manufactories" give employment to more than a third of the working population: but, since in Australia a large number of simple industries (such as chaff-cutting, wool-washing, and saw-milling) are called manufactures, the real manufacturing industry—as Europeans understand the term—is of much less importance.

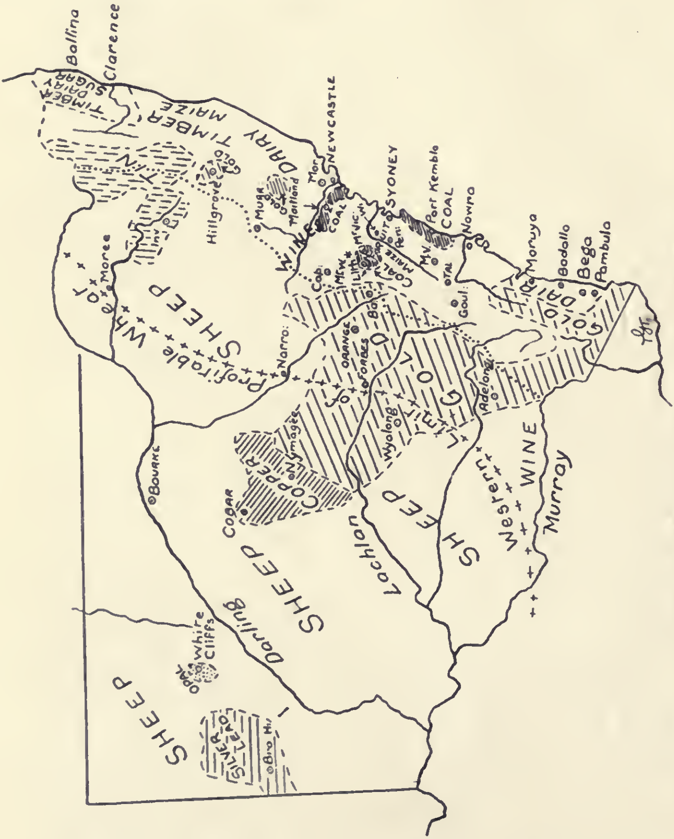


Fig. 100. Map of Industries of New South Wales. Mineral areas shaded. The line of dots is approximately the eastern limit of wheat areas.

We may estimate the value of an industry by two standards—by the value of its product, or by the number of people to whom it gives employment. So begin by studying two tables:—

*TABLE I.

N.S.W. PRODUCT-VALUES—AVERAGE OF LAST TEN YEARS.

Product.	Value in £1,000s.	Product.	Value in £1,000s
Wool	£10,843	Wheat	£2,373
		Butter	2,000
		Hay	1,716
Gold	984	Maize	768
Silver	2,255	Vegetables	500
Coal	2,360	Fruit	351
Copper	499	Sugarcane	144
Tin	181	Wine	62

Total pastoral products ... £16,077,300
Total mineral products ... £7,043,500
Total agricultural (including dairying) £10,407,000

*All figures in this chapter are taken from official sources.

TABLE II.

OCCUPATIONS OF THE PEOPLE, N.S.W. (CENSUS OF 1901).

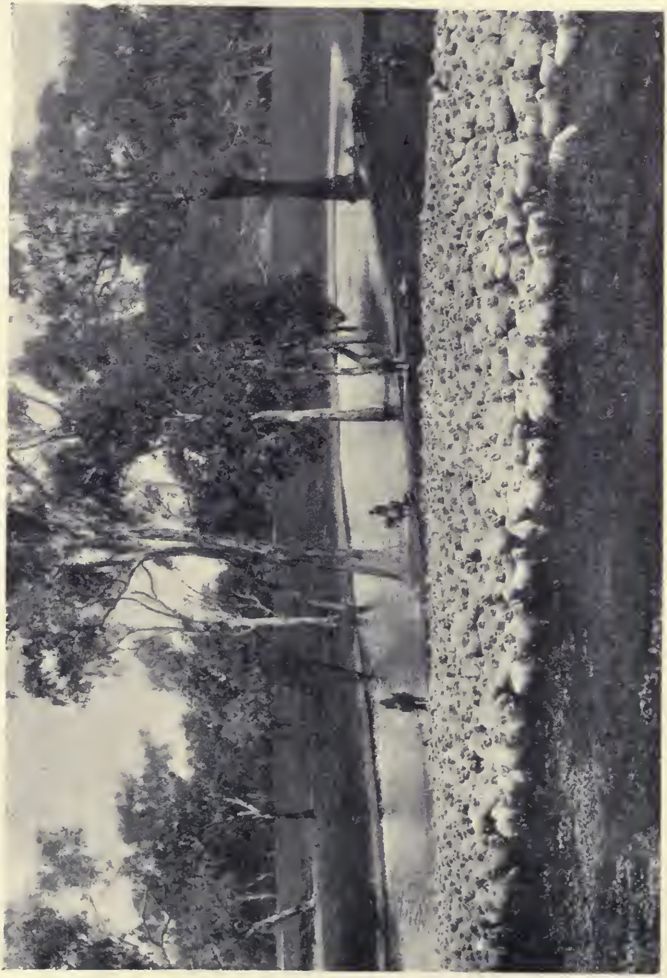
	Per cent.		Per cent.
Pastoral	5½	Commercial	14
Agricultural	14	Professional	7¼
Dairying	3¼	Domestic	13
Mining	7	Transport	7¾
Forestry	½	Other ...	9½
Manufacturing	16½	Independent	1¾
Total producers	46¾	Total producers	53¼

NOTE.—These percentages are calculated on the total number of "breadwinners," not on the total population of the State. Out of a hundred people in N.S.W., 42 are reckoned as breadwinners. and the other 58 as dependent on them—wives not working outside the home, children at school or younger, relatives not earning their own living, &c.

With the right-hand column of Table II. we have nothing to do just now: that will be discussed in Chapter IX. But. comparing the left-hand column with Table I., you will see that by the value-standard wool-growing is considerably the most important industry of the State, while by the employment standard farming is more important than wool-growing and mining put together. And if more detailed figures had been given, you would have been able to calculate that each station-hand's work yields nearly £300 worth of product, each miner's more than £160, and each agricultural employee's only £80 a year. (Of course that is not really true about the station-hand: it is the grass and the sheep that yield the great value, and the hand's work only prevents it from being a little less.).

THE PASTORAL INDUSTRY.

Wool has been New South Wales's standby from the first, and even now the State contains more than half the sheep of the Commonwealth, and exports more than half the wool. If you draw a line down the Barwon to Brewarrina, across country to Condobolin, and thence down the Lachlan and Murrumbidgee, the area west of this line (officially called the Western Division) is practically given up to wool growing, and may permanently remain so. Draw another line from Texas on the Dumaresq through Narrabri, Dubbo, Parkes, and Temora to Corowa on the Murray, and you have between the two lines a district (officially called the Western Plains and Riverina) (Fig. 101) which still holds the bulk of the State flocks, although inroads are being made on its area by wheat-growers, especially near the towns just named. East of the second line, between it and the main range, the flocks which used to cover nearly the whole of it have given way before the increase in cultivation; but the number of sheep has actually grown bigger, because on smaller estates more careful tending and feeding is possible, and so more sheep can be run to the acre. The same thing has happened on the tableland, except that much less land is given up to



Tourist Bureau, N.S.W.

Fig. 101. Flock of Merino Sheep, Walla-Walla Station, Riverina District, N.S.W.

wheat, and barley, oats, potatoes, and fruit-trees take its place; but the number of sheep is slightly increased, all the same.

TABLE III.

DISTRIBUTION OF FLOCKS, 1901 AND 1909.

District	1901	1909
Coast and Tableland	9,956,540	10,418,329
Western Slopes	11,671,524	12,506,324
Western Plains and Riverina ...	14,578,523	16,662,356
Western Division	5,522,953	6,615,569

TABLE IV.

SIZE OF FLOCKS, 1901 AND 1909.

	1901	1909
Under 1,000 sheep each ...	11,800	16,737
Under 5,000 ,, ,, ...	4,073	5,998
Under 20,000 ,, ,, ...	1,194	1,380
Above ,, ,, ,, ...	432	386

As time goes on, the number of sheep on the Coast and Tableland may increase a little, and is at any rate unlikely to diminish, though the size of the flocks in these districts will continually grow smaller as the system of closer settlement extends over them. In the Western Slopes, Western Plains and Riverina there may be a great falling off, because it is in those districts that the land now used for sheep pastures is especially good for wheat-growing. In the Western Division, where the low rainfall prevents permanent cultivation except in small patches with special care, flocks will increase year by year as owners learn to take more trouble and use artificial means of improving the pasturage and guarding against droughts, instead of leaving their sheep to fatten or starve as the seasons allow.

Since from the sheep you get both wool and meat, but the best wool comes from the smallest breed, the flocks of New South Wales are usually divided into two classes; the **Merino**, which give the fine wool for which Australia is celebrated throughout the world, and the coarse-wooled—often called **Crossbreds,** though nowadays many are as purebred of their kind as Merinos are—whose bigger bodies give more meat. Twenty years ago 39 sheep out of every 40 in the State were Merinos; to-day about 36 out of 40 are—the rest belong to big English breeds known as Lincolns, Leicesters, Suffolk Downs, and so on (from the English counties where they originated), or are crossbreds of the Merino with these breeds.

The value of the wool yielded varies not only with the number of sheep but with the price of wool in the world's markets. Thus in 1907, when wool in London fetched from 11¾d. to 12¾d. a lb., the value of the State's wool product was £17,185,100; in 1908, with prices between 9¾d. and 11¾d., it was only £12,680,000; yet the oversea shipments of wool for those years were 777,748 bales in 1907 and 915,617 bales for 1908. As for the **meat-product,** New South Wales in 1907 exported over half a million hundredweight of frozen or chilled mutton, of which almost three-quarters went to Britain.

Dairying.

The cattle-rearing industry in New South Wales is not of great importance except in connection with dairying. The export of beef for the years 1905-7 averaged 24,000 cwt. per year. The export of **butter** for the same period averaged 23 million pounds, worth about £1,000,000. And butter is only one of many dairy products—while the exported butter is not much more than a third of the total product. In 1908, for instance, the dairies of New South Wales turned out over 61 million lb. of butter, nearly 5 million lb. of cheese, and 9½ million lb. of bacon and hams.

The dairying districts lie mainly along the coast, especially in the far north, where the county of Rous alone contains 128,000 of the State's 528,000 dairy cows. Camden county with 43,000 comes next, and the coastal districts as a whole contain 77 per cent. of the total. In Camden and the rest of the Illawarra district the milk is chiefly used to supply Sydney, so that the butter-yield there is small: north of Newcastle the opposite is the case. The following table is interesting:

TABLE V.

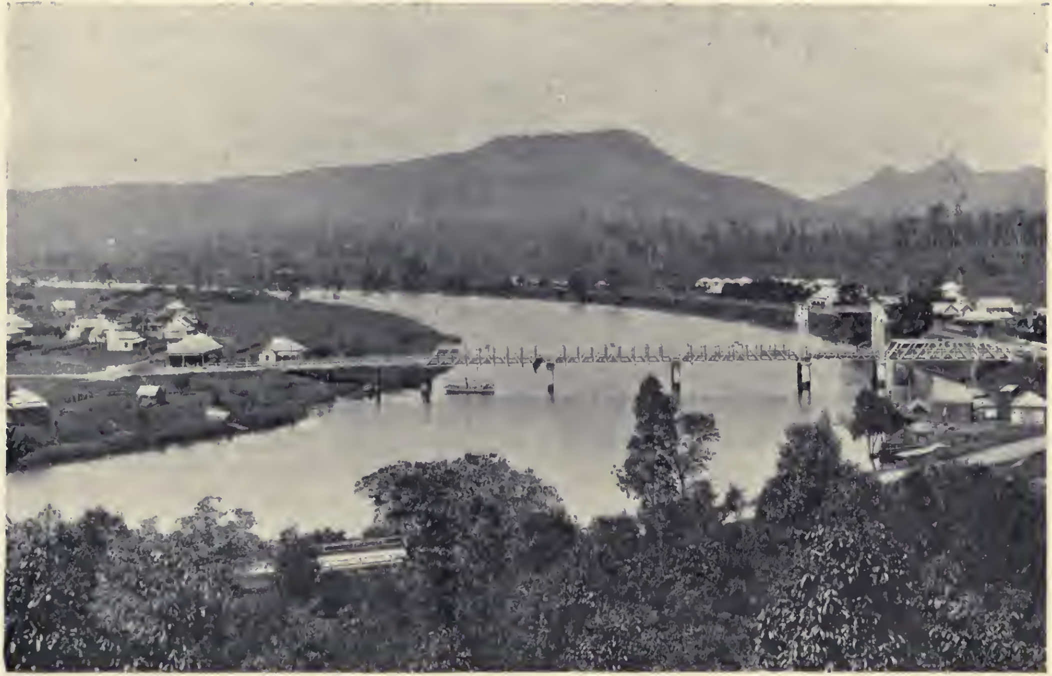
COMPARATIVE YIELDS OF MILK, BUTTER, AND CHEESE.

Percentage made in district	Milk	Butter	Cheese
North of Sydney	59	72	3
South of Sydney	23	15	87
Rest of State	18	13	10

And while the single county of Rous in the north is responsible for 28 per cent. of the milk-yield and 34 per cent. of the butter, the two southernmost counties of Dampier and Auckland produce 73 per cent. of the cheese.

Cattle outside the dairying districts are reared chiefly on the northern tableland, and in the county of Arawatta on its western border.

The **horse-breeding** industry is one to which the climate and soil of the State's eastern half are well suited. Though horses, being used in every sort of farm



Tourist Bureau, N.S.W.

Fig. 102. Tweed River at Murwillumbah Bridge, North Coast, N.S. Wales.

and station work, are scattered over the whole of New South Wales, the principal breeding districts are indicated by figures well enough: thus the area between Grafton and the Tweed (Fig. 102) accounts for more than 7 per cent., the Upper Hunter and the counties eastward for 10 per cent., the North-western Slopes for another 10, while the districts round Glen Innes and between Bathurst and Forbes are also notable for horse-breeding. About ten per cent. of the stock are thoroughbred, and about four per cent. fit for export; but the actual oversea trade is still small in comparison. The average number during the last five years for which figures are available (1904-8) was:—

To India	1,473 horses	worth	£32,154.
To other countries outside Australasia	1,699 ,,	,,	£45,768.

Seeing that the State boasts of nearly 600,000 horses and reckons about 27,000 of them fit for export, the trade seems capable of great expansion.

Among the other primary industries are **poultry-farming** (value of produce, about £1,000,000) and **bee-keeping**; as well as the **trapping of rabbits and hares**, which was worth over £600,000 in 1907 for its actual produce, besides its value to the farmer and squatter in destroying a very noxious pest. **Fisheries**, though the coast is a splendid fishing ground and the numerous lagoons are excellent breeding-grounds, have been much neglected hitherto; the appliances used by fishermen are primitive, and no improvement can be expected until capital is put into the business. The **oyster fisheries**, which in 1899 gave a yield of 20,000 bags, fell off by 1904 to 12,500 bags from nearly double the length of foreshore; but more care is now being exercised, and the yield increases steadily. The principal oyster beds are along the foreshores of the Hawkesbury and Manning estuaries.

FORESTRY.

Another much neglected primary industry is forestry. Nearly eight per cent. of the State's area is still forest land, and about half of that is reserved for other uses; but this represents the mere remnant of a much greater area, which has been denuded by settlers clearing land for their farms, or squatters ringbarking to ensure a greater yield of grass on their pasturages. What is left will, at the present rate of almost unchecked consumption, supply hardwoods for another 46 years and softwoods for only 27 years. A recent Royal Commission recommended large measures of re-afforestation, the permanent dedication of over 7,600,000 acres to forests, and the prohibition of the export of certain valuable hardwoods: but nothing has yet been done to carry out these or any changes.

The forests of the State are usually divided into scrubs, brushes, and open forests. The so-called scrubs are forests of cypress pine (*Callitris*), whose wood is strongly resistant to white ants, with interspersed belts of acacias and eucalypts; they occur west of the main range, the most important now being the Pilliga Scrub between Narrabri, Pilliga, and Coonamble. The brushes occur east of the range, especially in the basins of the Clarence and Richmond. They are softwood forests, including pines of the genera Araucaria and Podocarpus, cedars, rosewood, silky oak (*Grevillea*), tulipwood (*Harpullia*), coachwood (*Ceratopetalum*), and white beech (*Glemina*): these are all admirable furniture woods, and several are highly ornamental. The open forests consist mainly of gum (Eucalyptus), all hardwoods, of which the Ironbark is probably the most valuable, being extremely strong, and therefore used for bridge-building, girders, railway sleepers, and so forth. Tallow-wood and Blackbutt are used for floorings and street paving, Red Gum for piles, mine shafts, and other work where it comes in contact with the ground; Grey Box is of similar use, and so is Turpentine, which also stands immersion well, and is used for jetties and wharves. Roughly speaking, all the gums whose timber is straight and clean enough for sawmill are tough, durable, and useful for building.

The only active forestry work at present done by the State is in connection with the Gosford Nursery, from which young trees are distributed to municipal bodies and farmers. Public money has also been spent of recent years in thinning pine scrubs and red gum forests along the Bogan, Lower Murrumbidgee, and Murray.

AGRICULTURE.

Country that has passed out of the pastoralist's hands is now mainly devoted to various forms of agriculture. (The dairying lands of the coast were previously either brushes, haunted by the timber-getter, or alluvial jungle occupied for a short time by sugar-planters). The area under cultivation* has increased very spasmodically; up to 1892 it amounted to an acre per inhabitant or less—in the next eight years it rose from one to two acres per inhabitant—since then it has remained stationary as regards proportion, only increasing in almost exact ratio to the increase in population. In the earlier years, as is natural, the value of products per acre was bigger than to-day, since the richest land would, on the whole, be tilled first. These considerations will explain the following table:—

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*Including sown grass lands, which are omitted in Table VI.

TABLE VI.

AGRICULTURAL DEVELOPMENT IN N.S.W.

	1889	1894	1899	1904	1910
Area under crop, acres	798,966	1,206,992	2,204,500	2,542,919	3,174,864
Average per head of population	·8	·97	1·64	1·74	1·87
Value of products per acre	£4 3 0	£3 4 8	£2 4 3	£3 5 9	£3 8 9

It is hoped that coming legislation, both Federal and State, will encourage a much greater development of agriculture. At present Queensland and Tasmania are the only States proportionally less developed: Victoria has under crop 2.75 acres per inhabitant, and South Australia 5.83. Victoria, too, has actually a greater area under crop—nearly three and a half million acres—though her territory is so much smaller.

The cropped area is mainly devoted to wheat, hay, and green fodder; then come maize-fields, potato-paddocks, and orchards, but the latter group is much more profitable per acre.

TABLE VII.

AREAS AND VALUES OF PRINCIPAL CROPS.

	Percentage of total tilled areas.	Value, 1910.	Value per acre.
Wheat grain	63	£5,111,990	£2 11 4
Hay	20	2,699,660	4 5 7
Green fodder	4	422,410	3 11 0
Maize	7	798,560	3 15 1
Orchards, vineyards, and market gardens	2	863,560	15 13 0
Potatoes	1	400,570	11 4 3

The great wheat-district of the State lies along the western slopes of the main range, from Mundooran on the Castlereagh to Narrandera on the Murrumbidgee; but it is rapidly extending at both extremities, and will soon reach from above Narrabri to the Murray. (Fig. 103). Roughly speaking, it is bounded on the east by the rough hill-country, and on the west by the line of insufficient rainfall; but in places, especially on the upper Bogan, it is found possible to grow wheat profitably with a rainfall theoretically insufficient. Twenty inches is quite enough, provided the falls occur at the right time for (*a*) ploughing, (*b*) the successful sprouting of the seed, (*c*) filling the grain, in September and October especially. Besides this condition, the nature of the soil excludes certain areas within the rainfall line: the heavy black soil of the Gwydir and Macintyre basins, for instance, is difficult of tillage, and rich river-flats anywhere are wont to encourage the overgrowth of straw, making the crop less useful for grain than for hay.

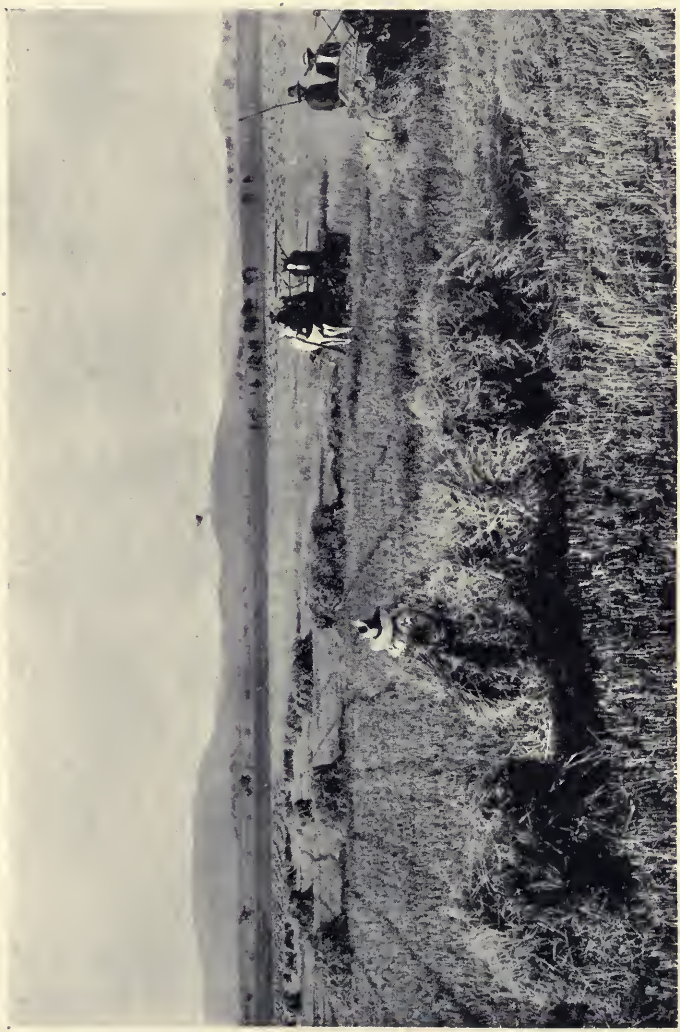
TABLE VIII.

CONNECTION BETWEEN RAINFALL AND WHEAT-YIELD.

[Yield-figures represent thousands of bushels.]

	Season of 1906-7.		Season of 1907-8.		Season of 1908-9.		Season of 1909-10.	
	In.	Yield.	In.	Yield.	In.	Yield.	In.	Yield.
N.W. Slope (mainly upper Namoi)	26	3,004	26	1,070	31	3,286	30	3,539
Central Slopes (Mundooran to Forbes)	25	4,789	21	2,033	18	1,455	25	5,793
S.W. Slope (Grenfell to the Murray)	30	4,250	18	2,482	20	4,042	23	6,107
Central Plains (Narromine and Upper Bogan)	18	2,263	14	599	13	354	20	2,614
Riverina (practically five eastern counties)	22	5,675	12	2,306	18	5,686	20	8,516

The average yield per acre is at present highest in the north, partly, no doubt, because the soil is still fresh, the land there having only recently been thrown open



Tourist Bureau.

Fig. 103. Harvesting: Tamworth District, N.S. Wales.

for agriculture. In the season 1909-10 it varied from 15½ bushels per acre on the North-Western Slope to 13½ on the Central-Western Plain; Riverina, which is the oldest of the great wheat districts, gave a return of 14 bushels.

Of the **hay** area 68 per cent. is devoted to wheaten hay, 23 per cent. to oaten, and about 8 per cent. to lucerne: but the greater yield of the last—partially due to irrigation—alters the proportions of the products to 60, 24, and 16. In favourable soil, with proper attention and suitable irrigation, **lucerne** can be made to yield eight crops a year, each averaging one ton to the acre. A good deal of this, of course, is used as green fodder, especially in the dairying districts, where also maize, sorghum, millet, and such grasses as *paspalum* are cultivated for the same purpose. Thus the North Coast has half a million acres down in artificial grasses, and about 8,500 in crops for green fodder: the South Coast has 170,000 in grasses and 16,000 in green fodder. The most important lucerne areas are round Tamworth and Inverell in the north and beyond Narrandera in Riverina; the Hunter Valley also grows a great deal for hay. (Fig. 104.)

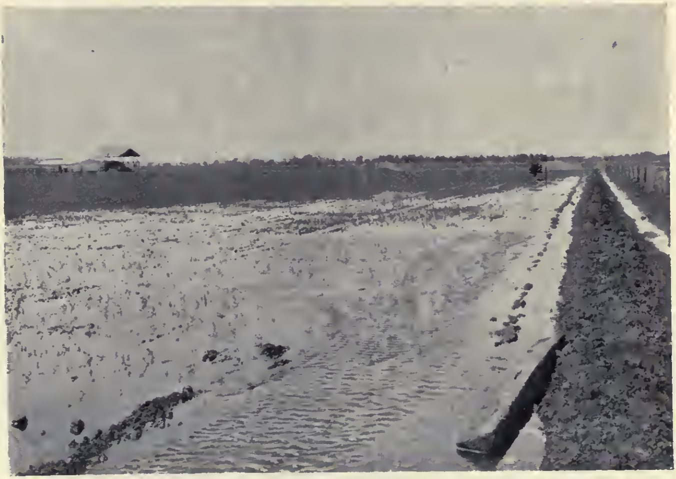
Maize, too, is largely a coastal crop, more than two-thirds of the State's yield coming from the coast counties north of Newcastle. The best average yield, however comes from the extreme south, where 44 bushels to the acre are obtained—the northern areas yield from 29 to 40 bushels.

In **root-crops** New South Wales does not by any means hold its own. Potatoes are grown mainly on the tablelands, the Bathurst districts producing nearly a third of the State's total yield of about 1,617,000 cwt.: but as much again is imported annually, mainly from

Tasmania. The county of Wellington produces more than half the State's onion crop—which is only about 24,000 cwt. in all; about eight times that quantity is imported, mainly from Victoria. The other root-crops are insignificant.

SUGAR-CANE.

Before the advent of the dairying industry to the north coast lands the lower valleys of the Clarence, Richmond, and Tweed were largely used for sugar-planting. In 1895 32,000 acres were thus occupied. Since then the area has decreased until in 1909 barely 17,000 acres were planted, and the yield (144,760 tons of cane) was the lowest for nearly thirty years. The majority of farmers cultivate sugar alongside other crops, or in conjunction with dairying. Coloured labour is responsible for about 6 per cent. of the product.



Works Dept., N.S.W.

Fig. 104. Flooding Lucerne Crops, Experimental Farm, Yanco, Riverina

Wine and Fruit.

The principal wine-making vineyards of the State are situated on the Murray near Albury, and in the Hunter valley between Pokolbin and Muswellbrook, and occupy about 1,300 acres in each of these districts. Vineyards which produce table grapes are more widely scattered, but occur chiefly in the county of Cumberland—as might be expected, since Sydney is the natural market for their sale. The Hunter valley vineyards are the richest, yielding over 440,000 gallons, and averaging 257 gallons per acre: the Murray vineyards yield about 162,000, and average only 97. There is a small output of brandy. Within the last few years a start has been made with fruit drying, and the district north of Wagga is especially suitable for this industry. The annual vineyard product, taking an average over the last six years, has been 917,000 gallons of wine, 29,500 gallons of brandy, and 3,600 tons of table grapes: in 1908 and 1909 about 117 tons of raisins were also produced.

The soil and climate of the State's eastern half are well suited to produce, in one district or another, nearly every sort of fruit except the tropical. Yet little advantage is taken of this suitability. Citrus fruits alone are produced up to and beyond the State's own requirements; seven-eighths of the orangeries are in the neighbourhood of Sydney—nearly 15,000 acres, producing over 610,000 cases of fruit annually (a case holds twelve dozen oranges). Excellent oranges are grown in the western plains on small areas irrigated with artesian water; but the output of fruit from this source, though capable of extensive development is as yet inconsiderable. As for the other fruits, on the tablelands English fruits do well, especially apples near

Bathurst; on the northern rivers bananas, pineapples, and pawpaws thrive, when anyone takes the trouble to raise them; peaches and passion-fruit grow well where-ever there are vineyards or orangeries. Yet, while exporting only about £33,000 worth of fruit—of which nearly two-thirds are oranges and grapes sent to New Zealand—New South Wales has to import from abroad £50,000 worth of dried fruits, £16,000 of preserved, and nearly £90,000 worth of fresh—largely bananas from Fiji; while from other Australian States she gets nearly £110,000 worth of dried fruits, £60,000 of preserved, and nearly £300,000 of fresh—apples, mainly, from Tasmania, bananas and pineapples from Queensland, and miscellaneous fruit from Victoria and South Australia. *Her fruit-product, that is, barely meets one-third of her demand.*

This astounding neglect of great natural resources seems due mainly to two causes—the scarcity of skilled and reliable labour, and the desire of nearly every man who takes up land to get immediate returns from his labour. When agriculturalists are willing to cultivate smaller holdings (irrigation settlements may help this along) and to wait a few years for greater profits—the average return from orchards for the last ten years was over £12 an acre—New South Wales may begin to develop its fruit-trade in proportion to its possibilities.

OTHER CROPS.

Many other branches of minor agriculture might easily find a home in the State, though little or nothing has yet been done to introduce them. Flax, for instance, was successfully grown here in the early days; on suitable soils it would be a very valuable crop. The

New Zealand flax grows well in many places, and sisal hemp—which Queensland is beginning to cultivate in bulk—thrives along the north coast. Cotton of excellent quality, broom millet, arrowroot, and olives, are other products already proved to thrive in one district or another. Only broom millet is cultivated from a commercial point of view. Tobacco, which is grown near Inverell, Tamworth, Bathurst, and Tumut, is partly in the hands of Chinese, who consider weight before quality; with care, and the help of expert advice from abroad, the State's tobacco-crop could be made a valuable asset.

In connection with agriculture mention must be made of the State experimental farms—fourteen in number—the Hawkesbury Agricultural College, and the experimental plots which the Government establishes in almost every district on private land, to be worked by the farmers themselves under Government supervision. At the College about 200 resident students are given instruction in every branch of agriculture; other students, at the Wagga, Bathurst, Cowra, Berry, Glen Innes, Grafton and Wollongbar farms study the agriculture specially suitable to the district. At Wagga wheat-culture in dry climates and the production of dried fruits are the specialities; at Bathurst orchardists' work and the cross-breeding of sheep; at Wollongbar, in the Richmond valley, dairying and the cultivation of artificial grasses; Berry is a stud farm for dairy cattle. The other farms—some with limited accommodation for students—are near Nyngan and Coonamble (for dry farming in the arid lands of the plains),* and at the Pera Bore near Bourke (for artesian cultivation). There is also a viticultural station at Howlong on the Murray, and Raymond Terrace on the Hunter, where experiments are made with pest-resisting vine-stocks.*

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*At present wheat is successfully grown, experimentally, at the Nyngan

Mining—Coal.

The mineral industry in New South Wales began with coal-mining, and coal is still the most valuable of the State's mineral products. Draw a line on the map from Gunnedah to Cassilis and then almost due south to the coast at Ulladulla, and a second line from Gunnedah south-east to Port Stephens: the whole area between these lines has underlying it what are called the Permo-Carboniferous Coal Measures, which supply good marketable coal, fit to compete with the product of other countries, wherever they are reached by mining. Here and there—at Clifton in North Illawarra, for instance, where coal was found in 1796 lying on the seashore, and in the deeper valleys of the Blue Mountains—the seams are visible on the surface; at Newcastle also coal was found in 1797 lying close to the river bank, and the hint thus given was slowly taken. At first the Government itself worked a mine by convict labour, and cargoes were sent to the Cape of Good Hope in 1800 and 1801. In 1826, however, the Newcastle mines were handed over as a monopoly to the Australian Agricultural Company, an English company which had taken up a million acres of land a little further north: in 1846 this monopoly was revoked,

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Farm, where rainfall is 15 inches annually. If this proves successful commercially Mr. H. C. L. Anderson, M.A., Director of Agriculture, estimates that there are fifty millions of acres of similar land with similar rainfall available for wheat-growing in this State.—Editor.

*At Dural there is an experimental station for studying how old abandoned orchards may be recuperated.—Editor.

and mining companies spread themselves for some distance along the southern edge of the Hunter valley. The same seams were afterwards worked in North Illawarra (the Bulli field) and at Lithgow, on the western edge of the Blue Mountains; they pass under Sydney at a depth of about 3,000 feet, and are worked there from shafts sunk at Balmain.

A lower series of seams is worked near East Maitland, and was formerly worked at Thornton and Tomago. A still lower series is now worked on a large scale to the west of Maitland as far as Cessnock, and was formerly worked at Greta. This series known as the Greta Series is also found towards the head of the Clyde River to the south-west of Jervis Bay. Further north a mine is open at Curlewis on the Liverpool Plains, and another in the neighbourhood of Muswellbrook: beyond Inverell, too, near Ashford is a thirty feet seam of steam coal probably belonging to the Greta Series.

For the geology of the coalfields you must read Chapter XVII., in which also information is given about some less important mines on the Clarence River, whose coal is only useful for local use.

The following table shows the comparative importance of the three great fields:—

TABLE IX.

QUANTITY AND VALUE OF COAL RAISED IN DISTRICTS.

District	Quantity		Value per ton			
	1910	Average of ten years	1910		Average of ten years	
			s.	d.	s.	d.
Northern (Newcastle, Maitland, Greta, Curlewis)	5,366,975	4,907,270	8	1·4	7	8
Southern (Helensburgh to Wollongong, and Berrima)	1,875,009	1,676,673	6	1·7	5	8¼
Western (Lithgow to Piper's Flat)	931,524	750,249	5	5·5	5	0

The Newcastle coal is the best for gas-making and household use, while the Illawarra and Lithgow coals are steam-coal: the Illawarra product is much used by the British naval squadron and the ocean-going steamers. The Northern field employs 13,000 men in 98 collieries, the Southern nearly 4,000 in 21, and the Western about 1,345, in 29.

Closely allied to the coal deposits are the **shale-beds** which occur in the Blue Mountains and on the southern tableland. Those at Hartley Vale were discovered in or before 1845. Both at Hartley and at Joadja Creek, near Mittagong, the deposits are practically exhausted, and the only mines now active are at Wolgan, in the Capertee Valley, where the Commonwealth Oil Corporation is hard at work. The average yield of the last ten years (1901-1910) was 47,161 tons worth 13s. 9.39d. per ton. The figures for 1910 are 68,293 tons worth only 9s. 11d. The industry employs 426 men.

GOLD.

Although the gold-yield of recent years is small in comparison with the early records, yet its total value to the State is almost as great as that of its coal. Reports that gold was to be found in certain riverbeds were made to the Government on several occasions between 1823 and 1844: but the discovery which led to results of commercial value —and, incidentally, to a great influx of population and the almost complete reconstruction of Australian society—was made by Edward Hargraves in 1851. The greatest amount ever recovered in a year dates from the very next year, 1852; the smallest to 1888, when the State was otherwise so prosperous that no one needed to go gold-digging for want of other employment. Indeed, for the last thirty years the gold-yield of New South Wales has been an upside-down sort of index of its general prosperity. The great financial crisis of 1893 resulted in a jump of the gold-figures from £650,000 in 1893 to £1,157,000 in 1894; when gradually returning commercial confidence had lowered these figures to £685,000 in 1902, the great drought of that year drove them up again to over the million in 1903. Of course actual discoveries have their effect, too: thus the development of the mines at Wyalong in 1897 is reflected in the 1899 rise from twelve to sixteen hundred thousand pounds, and the opening of the Cobar field helped to keep the figures of 1904-7 practically at the level of 1903, despite the increasing prosperity of the State in other directions.

The districts named are still the principal gold-centres; Wellington, Adelong, and Araluen (where dredges are much used), together contribute about two-thirds of the amount produced at Cobar alone. Nearly all over the State deposits may be found: they have been worked profitably at Mount Brown in the extreme west, at Delegate in the extreme south, and on the seashore near the Richmond River in the extreme north. The industry employs over 6,000 miners, of whom about 200 are Chinese working on alluvial: and it is interesting to note that their work has become more efficient year by year of late, mainly owing to the growing predominance of dredging and scientific mining methods over the older slipshod individual system. Thus in 1902 drought prevented dredging to a great extent, and much gold was won by prospectors otherwise employed: the yield per miner was under

£65. Next year, when the regular mines were at work again, but prospectors were still many, the yield ran up to £96. As the casual element died out of the industry, the proportion increased to £113 in 1905, and in 1908 each miner's product was worth £150.

OTHER METALS.

The **silver-mining** industry of New South Wales really dates from the discovery of the Broken Hill field in 1883. This is now one of the world's principal mining centres; yet it began with a syndicate of seven station-hands, and the Proprietary Company, still the most important on the field, started with a working capital of only £15,000, and has made but one call during its existence. Broken Hill maintains over 90 per cent of the silver-miners in the State; there are also small mines worked on the northern tableland and near Yass, and a field which has become valuable has been opened in the gullies of the main range about sixty miles south-west of Sydney. The State's silver product is worth over two million pounds yearly, and the lead and zinc which are mined along with it make up a total value of about three millions. To obtain this between seven and eight thousand miners are employed.

Of the other metals copper and tin are the only important New South Wales products. **Copper** was the first metal to be mined in the State, the earliest mines dating from 1845: it occurs near or in conjunction with gold, especially along the line from Cobar to Mount Hope, where the principal mines are situated; other mines are worked near Lake George, and in the highly mineralized districts between Armidale and Inverell. To extract it nearly 3,000 miners are employed, but the value of their work has been decreasing lately, owing to the lower price obtainable for copper in the world's markets. Thus, while a miner in 1908 produced $3\frac{1}{3}$ tons of copper against $2\frac{2}{3}$ in 1907, his product-value dropped from £193 to £180.

Tin, though found in half a dozen districts of the State, can only be worked for profit in the western valleys of New England. Its recovery—mainly by dredging—employs some 2,400 miners, of whom nearly 400 are Chinese. As in the case of copper, their efficiency has slightly increased of late years, but the lower price of the metal has counteracted this and reduced their product-value from £93 to about £84.

The only other mineral products worth mention are **iron**—the ore of which is widely distributed, but rarely worth working, because the metal can be so cheaply obtained from Europe—and **opal**. The principal field is at White Cliffs, north-west of Wilcannia.

The following table shows the comparative importance of the various mining industries, both on the whole and in recent years:—

TABLE X.

	Values to end of 1910.	Values, 1910.	Miners employed. Average, 1906-10
Coal	£62,260,507	£3,009,656	17,105
Gold	57,991,493	802,211	6,696
Silver, silver-lead and ore ...	52,296,959	1,861,479	8,240
Copper	10,614,209	486,257	2,773
Tin	8,682,446	228,156	2,698
Zinc	4,358,691	1,289,634	...
Shale	2,251,081	33,896	344
Opal	1,237,899	66,200	...
Iron	1,837,662	161,948	...
Lead	1,526,597	248,561	...

The Manufacturing Industry.

As was said at the beginning of this chapter, the word "manufactory" has a wider meaning in Australian statistics than in the ordinary usage of life. One is inclined to think of establishments where clothes, boots, implements, and so on are made—not of those where wool is scoured, milk is made into butter, newspapers are printed, and so on. Also one thinks of places employing a large number of hands; but the Australian figures include all works where any machinery is used, and all other works where four hands at least are employed. A table will show most quickly which class of establishments employs most workers, distributes most wages, and has the most valuable output:—

TABLE XI.

Wages, Employees, and Output of N.S.W. Factories, 1908.

No.		Capital * sunk °	Employees, number	Wages paid °	Value of work done °
40	Smelting works ...	1,214	3,678	521	4,248
148	Butter factories ...	346	928	85	2,739
58	Ice and refrigerating	633	811	80	2,481
68	Flour mills ...	546	792	82	2,210
64	Wool-scouring works	181	1,468	93	1,975
385	Sawmills ...	686	4,127	327	1,479
328	Printing works ...	907	6,567	588	1,400
26	Railway workshops	1,259	5,688	668	1,281
128	Engineering ...	547	4,014	404	1,127
1	Sugar refinery ...	446	487	60	1,123
12	Tobacco factories ...	279	1,309	98	945
37	Breweries ...	578	885	110	934
82	Tanneries ...	160	928	82	898
105	Boot factories ...	212	4,650	303	1,080
81	Slop clothing ...	62	5,072	235	807
293	Tailoring ...	56	4,242	284	800

* In land, buildings, plant, &c. ° In £1 000s.

Notice that nearly the whole list is made up of establishments treating the raw products of the State, mainly to make them fit for food or for export. Of those which turn out finished articles (apart from food) engineering works and boot factories are the most important: others not mentioned above are soap and candle works (employing 553 persons and turning out £442,000 worth of goods), hat and cap factories (1,221; £176,000), coach and wagon works (2,213; £419,000), and furniture factories (1,951; £380,000). The clothing and tailoring work-shops deal largely in imported stuffs, though the State has five woollen mills treating home-grown wool, employing 455 persons, and manufacturing 525,000 yards of cloth.

These figures are in themselves not very noticeable except for their smallness; but they are a considerable advance on those of a few years ago. It is not worth while to give detailed figures of earlier years corresponding to those set forth above; but it is worth noting that since 1901 the product of soap and candle factories has, judging by value, increased 32 per cent.; that of metal works about the same; that of textile factories about 72 per cent.; that of coach factories about 67 per cent.; and that of furniture factories about 48 per cent. This increase of work done in the State is only partly due to the increase of population. A good deal of it represents work that used to be done in Victoria before Federation brought with it inter-State freetrade; a good deal also has replaced imports now shut up by the Federal protective duties. Thus, too, since factories have begun to receive encouragement, they have also begun to export manufactured goods to a small degree: the export of locally made apparel has nearly trebled since 1905, that of india-rubber manufactures has more than trebled, machinery has more than doubled; wagon exports have gone up 80 per cent., metal manufactures 50, boots and shoes 43, soap 38. The actual figures are insignificant, compared with the exports of *really* manufacturing countries: but *the* fact of steady increase is both significant and hopeful.

Most of the factories are situated in or near Sydney, because (*a*) the bulk of the population is close at hand, (*b*) all the State railways centre there, and so access is easy to any part of the country, (*c*) it is the seaport, (*d*) coal is not far away. The country factories are mostly saw-mills, flour-mills, butter-factories, wool-scouring and chaff-cutting works, brickworks, and so on. The development of recent years is almost entirely metropolitan: thus the number of hands employed increased between 1900 and 1908 in the country districts from 22,111 to 28,124, or 27 per cent: but in the metropolitan district the increase was from 38,668 to 60,974, or 57½ per cent.

The power used is generally steam. Within the metropolitan area and in a few country towns gas engines are sometimes used; and about 13 per cent. of the total horsepower is credited to electricity, but this itself is almost entirely developed by steam-engines. A few of the coastal rivers—and one or two of the inland streams, if properly dammed—may in future provide driving power for machinery: but this source of power is as yet practically untapped, and is unlikely to become of much importance in comparison with steam.

CHAPTER XX.—TRANSPORT AND COMMUNICATION.

(A. W. JOSE.)

The early history of New South Wales has shown us how circumstances conspired to make Sydney the all-important centre of the colony. Its unequalled harbour made it a natural *depôt* for oversea commerce; and the semi-absolute form of government, only controlled for many years by the authorities in London, intensified the importance of a seat of government which was also the port of arrival from London. For these reasons the first need of every settler was communication by an easy and as direct route as possible with Sydney, where alone he could market his produce and obtain his supplies, and where resided those high powers whose laws and regulations could make or mar his fortune.

When, therefore, in Macquarie's time settlement began to spread beyond the County of Cumberland, roadmaking from Sydney into the newly opened districts became the immediate task of the Government. Bathurst, Goulburn, and Maitland were thus linked up with the capital by 1832, and a little later the **Western Road** was extended through Orange to Molong, and Wellington, the **Southern** through Yass and Gundagai to the Murray, and the **Northern** over the Murrurundi Pass to the Liverpool Plains. Practically no attempts were made for many years to connect the inland country directly with the coast to eastwards: that would in most cases have meant making another costly road over difficult ranges, only to reach some small port from which produce must still be transhipped to Sydney;

it seemed simpler and cheaper—at least for the central Government, which was the road-constructing authority—to connect all inlanders by easy tracks across the more level country with the three well-made hill-crossings already mentioned.

With a few additions, and one serious alteration, the framework of the State's roads remains to-day as Macquarie and Brisbane left it. A shorter way across the Blue Mountain plateau—still known as "Bell's Line," from the surveyor who planned it—was for a long time used as a stock route, but with the extension and cheapening of the railway service has fallen altogether into disuse. The same or similar reasons have caused the almost total abandonment of the old Northern Road between Sydney and Maitland; Hunter River traffic now goes to Newcastle. New roads have been made from Sydney direct to Bulli and along the south coast districts, from near Newcastle to and along the north coast districts. And a few cross-connections have been made between the plateau and the coast below it, of which the roads from Braidwood to Moruya, from Moss Vale to Nowra, from Campbelltown to Bulli, from Armidale to Kempsey, from Glen Innes to Grafton, and from Tenterfield to Lismore are the chief. But the whole network of road-traffic inside the coastal ranges still hangs on the frame provided by the three great roads. Officially, by the by, there are four—the Southern, from Sydney to Albury, 385 miles long; the South Coast, from Campbelltown to Bega, 250 miles; the Western, from Sydney to Bourke, 513 miles; and the Northern, from Morpeth to Maryland, 405 miles. A look at the map will show that the official South Coast road is the one mentioned above, with the Campbelltown link substituted for the direct Sydney-

Bulli section; and that the official Northern road is the old road, reckoning from Morpeth (the head of navigation on the Hunter) instead of from Newcastle, and extended up to and along the plateau instead of down the Liverpool Plains. This latter deviation was caused by the desire to get direct road communication between Sydney and Brisbane—whereas the older track was aimed at the Darling Downs, which in the early days sent wool, &c., to Sydney or Newcastle.

RAILWAYS.

The first railways in New South Wales were begun by private enterprise. But it soon became clear that the capital likely to be invested in such undertakings by private people would build only short lengths of line, and that, while long lines towards the interior would not be directly profitable to investors for many years to come, they would be very valuable to the country as a whole. It therefore seemed natural that the central Government, which already managed the main roads, and which represented the country as a whole, should take the risk of borrowing large sums of money to build the necessary railways, and should therewith take over the management of lines already in working order.

At first the lines grew but slowly. The great disadvantage of Sydney has always been its severance from the rest of the State by mountain ranges of very rough character. The steep grades on the roads must for railway purposes be avoided by heavy tunnelling or long deviations, which cost much money; and the colony was not rich enough to borrow much at a time. On the Western line of traffic, for instance, it took six years (1862-8) to build the railway from Penrith to Mount Victoria—42 miles—and eight years more (1868-76) to prolong it to Bathurst, 69 miles further on; both the ascent on the Sydney side and the descent of the plateau towards the west had to be accomplished by zigzags, the one on an open hillside, the other (the

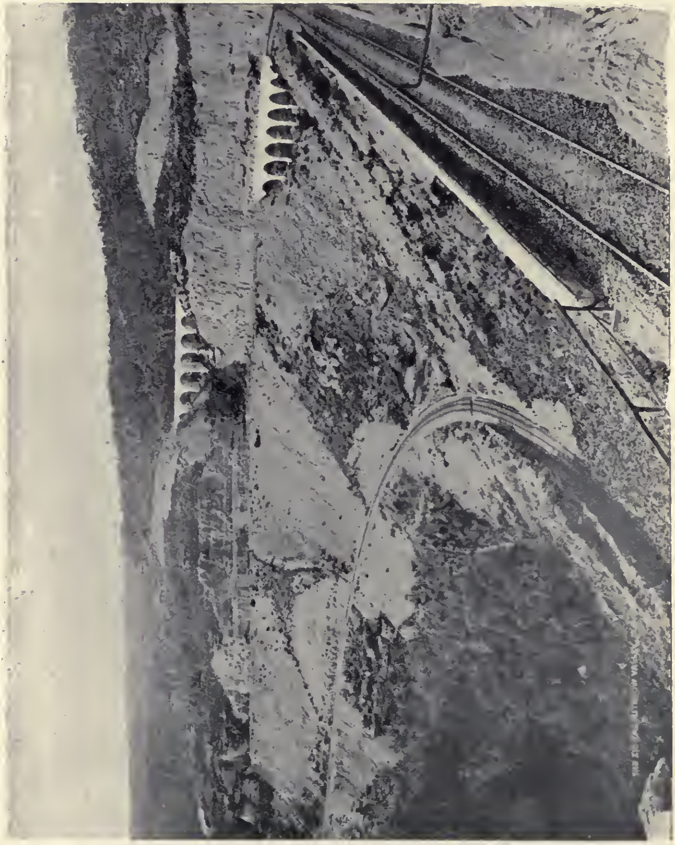


Fig. 105. The Great Zig-zag Railway, Lithgow Valley.

Tourist Bureau N.S.W

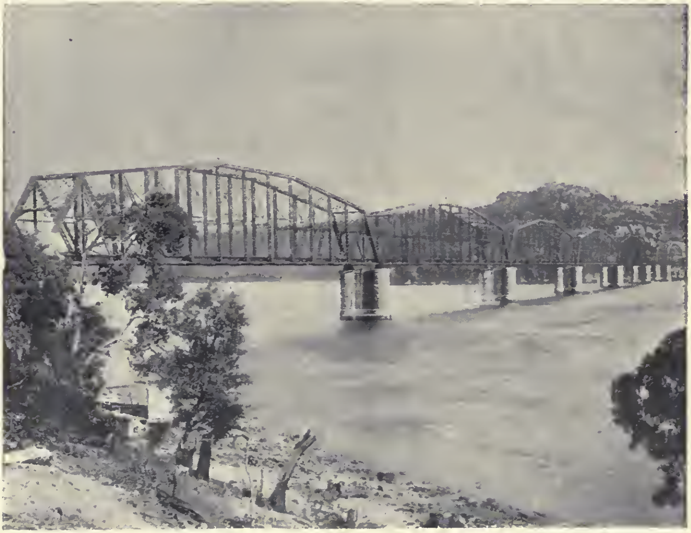
Great Zigzag, still one of the sights for tourists) by huge masonry embankments and viaducts down the side of a gorge. (Fig. 105.) Southwards the line to Goulburn was made over easier tableland by 1869; thrust out westwards, to avoid the steep drops of the road to the Upper Murrumbidgee valley, it reached Albury by a great curve in 1881. The Northern line began at Newcastle, and ran up the Hunter valley (almost on the road's track) to Tamworth in 1878, to the Queensland border ten years later: while the very next year it was joined up with the colony's other lines by a coastal line from Newcastle to Sydney, whose most important link is the great Hawkesbury River bridge. (Fig. 106.)

As with the roads, so with the railways, the framework is made up of these three lines, all connected with and depending on Sydney. Only three lines in the State, indeed, have not Sydney as headquarters—a private extension to Broken Hill, in the far west, of the South Australian State line, a small private line from Deniliquin joining the Victorian State line at the Murray, and a section of the North Coast line between Grafton on the Clarence and Murwillumbah on the Tweed, which will eventually be linked with Sydney by the main North Coast Line now in process of construction.

To-day the State railways may be classified as follows:—

(*a*) The main Southern Line, from Sydney *viâ* Goulburn and Cootamundra to Albury; with tableland branches to Crookwell, Cooma, and Tumut, wheatland branches to Temora (thence to Wyalong and to Barellan), Finley, Clear Hills, Corowa, and Germanton; and an extension to the pastoral country at Hay. [Main Line 392 miles, branches 788½.]

(*b*) The main Western Line, from Sydney to Bourke; with branches to Richmond on the Hawkesbury, to the shale mines of Newnes (privately owned), to pastoral districts (passing through wheatlands) at Dunedoo, Coonamble, Warren, Brewarrina, Tullamore, Condobolin, and Forbes; also to copper mines at Cobar and gold mines at Peak Hill. [Main Line 508 miles, branches 628.]



Tourist Bureau, N.S.W.

Fig. 106 Hawkesbury Railway Bridge, N.S. Wales.

(*c*) A branch from Southern to Western Line, *viâ* Young and Cowra, with wheatland spurs to Grenfell and Canowindra. [114 miles, spurs 55.]

(*d*) The Sydney-Newcastle Line. [104 miles.]

(*e*) The Northern Line, from Newcastle to Wallangarra on the Queensland border; with branches through wheatland to the pastoral country at Walgett, Collarendabri, and Moree (hence back to wheatland at Inverell); also a spur from Tamworth to Barraba. [Main Line 393 miles, branches 621.]

(*f*) The North Coast Line, technically a branch of the Northern, but probably when finished the main line to Brisbane; the sections towards the Manning River are under construction, and the Grafton-Murwillumbah section is working. [147 miles.]

(*g*) The South Coast Line, from Sydney to Bomaderry (across the Shoalhaven River from Nowra). [92 miles.]

The obvious needs of this system, which will probably be satisfied within the next few years, are (i) one or two lines connecting the main systems, especially the northern with the western, and (ii) a prolongation of existing lines westwards, either from Cobar or from Condobolin, to the Darling and Broken Hill. The Northern-Western connection is doubly necessary, both as a means of transferring stock from dry to watered districts in drought-time, and as a measure of defence; for at present the only link between the whole northern system—that is to say, the Queensland lines as well as the Northern Line of New South Wales—and the whole southern system—also including Victoria and South Australia—is the Hawkesbury bridge, which an enemy could surprise and destroy with the greatest ease. These needs have long since been acknowledged;

the delay in satisfying them is due largely to disputes about the best route in each case.

The State has now 3,764* miles of line open for general traffic, of which only 141 miles are privately owned. The uniform State Gauge is the British 4ft. 8½ in.; so that at each border transhipment is necessary, the Victorian gauge being 5ft. 3in., and the Queensland one 3ft. 6in. The private lines have adopted the gauge of the State with which they connect —the Deniliquin line that of 5ft. 3in., the Broken Hill line that of 3ft. 6 in. which South Australia uses on her northern lines. The cost of constructing and equipping the **State** railway has been close on forty-eight million pounds—averaging £13,140 per mile open, and being thus the most costly in the Commonwealth, though the comparatively large population which they serve brings the "cost per head of population" down to £29, the lowest on the continent.

The Government also owns and manages 104 miles of electric tramway in Sydney and its suburbs; and 47 miles of steam tramway, mainly in Newcastle and its suburbs, Broken Hill, and Parramatta. There are three private tramways in the State, in all 7 miles long.

WATER TRANSPORT.

The railways just described tap the greater part of the fertile inlands and tablelands, but leave the coast badly served. This results from the State's physical features: the main range is so close to the coast that in many places its rough foothills and deep, narrow gullies come almost to the shore, and make the construction of a line at right angles to them extremely expensive. Water carriage, therefore, is far cheaper; and, if the river mouths which mostly form the harbours were not so blocked by sand-bars as to prevent large vessels from using most of them—also if the river courses were not so winding and shallow—no railway could compete against regular steamer services. State Governments, indeed, have put off as long as possible the coastal railways just because there was an alternative, if inconvenient, method of sending the produce to Sydney.

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*The figures given on the previous page sum up to more; but in them the Sydney-Strathfield line is counted three times over, and the Strathfield-Granville section twice. All figures in this chapter are the official records for 1908-9.

To north coast ports a regular service is maintained by two small companies, one taking Port Macquarie and Hastings River traffic, the other serving the remaining ports; while a third company gives a daily service to and from Newcastle. Another company regularly serves the South Coast ports. And, both north and south, a number of small steamers trade frequently but irregularly. Navigation along the coast is naturally easy, as there are few dangerous reefs or currents, and few points of land projecting far into the sea; the State Government, moreover, has in time past erected 13 light-houses and 8 other lights that are visible at least ten miles from shore.

As for inter-State services, two large companies connect Sydney with Tasmania—also with New Zealand—and five with the other mainland States; one series of steamers runs from Sydney to Fremantle in Western Australia, another from Melbourne *viâ* Sydney to the North Queensland ports, going once a month as far as Burketown in the Gulf of Carpentaria.

River navigation is comparatively unimportant. Along the coast the small steamers that trade from Sydney run up the rivers for varying distances; on the Richmond there is a daily service between Ballina and Lismore, and one on the Tweed from Murwillumbah to Tweed Heads, linking up the North Coast Railway with the Queensland railways. The great inland rivers have too intermittent a flow to allow of a regular service. Specially constructed boats ply up the Murray to Echuca, and up the Darling to Bourke, when there is water enough: in exceptional years boats have even reached Albury and Brewarrina, but Menindie, Hay, and Echuca are the ordinary limits of navigation, and they only for about six months in each year.

The ferries plying on Port Jackson and up the Parramatta River are in the hands of private companies. They carry about 60,000 passengers a day.

COMMUNICATION.

The postal and telegraph services of the State are part of the Federal Post-Office, but are managed in the first place from Sydney.

With the world outside Australasia communication is maintained

(*a*) By three submarine cables—two controlled by a private company, which run west and north to join up with the great European cable systems; one owned by Great Britain, Canada, and Australia jointly, which runs across the Pacific Ocean to join the Canadian land lines at Vancouver (none of these cables start from New South Wales itself).

(*b*) By many lines of steamships, the principal of which carry mails, and are subsidized therefore by various Governments; for nearly all of these Sydney is the Australian head-quarters, though, to save as much time as possible, the mails are taken by rail either to Adelaide or Brisbane, and embarked there.

Of these lines the most important are—

The **Orient** line, subsidized by the Commonwealth, taking mails by the Suez Canal route to Europe;

The **Peninsula and Oriental** line (usually known as the P. & O.), subsidized by the British Government, taking mails by the same route;

The **Messageries Maritimes**, subsidized by the French Government, taking mails by the same route;

The **Nord-Deutscher-Lloyd** (North-German-Lloyd) line ("N.D.L."), subsidized by the German Government, taking mails by the same route;

The **Aberdeen**, **White Star**, and **Blue Anchor** lines (the last now a branch of the P. & O.), taking the route round South Africa, and carrying mails to Natal and the Cape Colony at fixed rates of payment;

The **Canadian-Australian** line, subsidized by the Australian and Canadian Governments, taking mails to Canada, and to Europe by that route;

The **Eastern and Australian** line, partially subsidized by the Government of the State, taking mails to China;

The **Nippon-Yusen Kaisha** ("N.Y.K."), subsidized by the Japanese Government, taking mails to Japan.

The joint result of all this traffic is that New South Wales sends and receives mails weekly—twice a week for two weeks out of every four—to and from Britain, Europe, and India; about three times a month to and from South Africa; once every four weeks to and from Canada direct, and about twice a month to and from Eastern Asia. There is also monthly mail communication with the islands of the Western Pacific, and—*viâ* New Zealand—with the Eastern Pacific and San Francisco.

Inter-State mails are carried daily by train, and by almost every steamer engaged in the inter-State services, which have been mentioned earlier in this chapter.

The State's internal mail arrangements are the most extensive in Australia. 2,492 offices collect the mails; in distributing them over 40,168 miles of route the mailbags travel nearly ten million miles a year. 1,290 telegraph stations, connected by 34,000 miles of wire, deal with nearly eight million messages, of which 212,000 odd are cablegrams. The telephone branch serves 5,633 telephones in Sydney itself, 10,759 through 28 suburban exchanges, and 6,022 in the country: it has also connected Sydney with Melbourne, and with 194 country towns in the State, Forbes—nearly 300 miles west, being the most distant.

CHAPTER XXI.—TRADE AND COMMERCE.

(A. W. JOSE.)

In Chapters XVII. and XIX. we discussed the commodities which New South Wales produces. The processes of trade, which are now to be discussed, deal (*a*) with the disposal of those products, and (*b*) with the acquirement by citizens of things not produced within the State. The latter is called the import trade: the former may be internal or export trade, according as the products are consumed within the State or sent beyond it, and the export trade is again divided into inter-State and oversea trade according to the destination of the goods sent away. (Remember that Tasmania is counted as part of Australia, not as a place oversea.)

Internal trade is a thing one can only guess at. No official statistics are kept, and none could be: the only possible method of estimating it is to take the production figures and deduct from them the amounts known to have been exported. But it is comparatively easy to see what articles are dealt with internally. In Chapter XIX. we divided products into four primary and three secondary classes:—

Primary—Wool, metals, timber, eatables;

Secondary—Manufactured eatables, other manufactures ready for use, things partially treated so as to be ready for export.

Now the primary foods (*e.g.*, milk) must of necessity be almost all consumed within the State; so are most of the manufactured eatables (*e.g.*, butter, flour, sugar, etc.); so are nearly all the manufactures ready for use, for a reason to be explained later. On the other hand, most of the wool and metals, and the things made ready for export (*e.g.*, scoured wool, partially smelted ores, etc.) become oversea exports. Timber is, as a matter of fact, mainly used within the State. The important exception to this general rule arises from the discovery some years ago of a method whereby eatable produce could be kept wholesome during a long and hot voyage; all the big steamers that trade between Australia and Europe are now fitted with refrigerating chambers, in which meat, butter, fruit, and such perishable products are kept either frozen or at least chilled, so that they can be sold in Europe practically as fresh as when they were put on board.* For this reason New South Wales is able to dispose of a much larger proportion of her eatable products by export trade than would otherwise have been possible.

The immediate centre of any **internal** trade is the township of the producing district, which probably has several mills and other factories to work up the raw material, and a railway station from which to send it to other markets. But—since, as we saw in Chapter XX, the State railways all centre on Sydney—the only important centre in the State is Sydney, which is also, of course, the largest town and the only mercantile port of any size: for Newcastle has hitherto been almost wholly confined to the coal-trade. Moreover, the railway time-tables and rates of freight are so arranged as to encourage the concentration in Sydney even of the State's internal trade; for, owing to this arrangement, it is often cheaper and quicker to send produce there for redistribution within the State than to send it direct from the growing to the consuming district.

However, when one speaks of trade or commerce, one usually means **inter-State** or **oversea** trade.. It is easier to get accurate figures about these kinds of trade, and they are of more importance for the merchant on a large scale; internal trade is carried on to a very large extent by traders in a small way of business, who work each for his own hand and are not much interested in big general figures. But you must remember that this local and internal trade, little as we may know of it accurately, is of very great importance to the country's welfare; and the trade policy of the Commonwealth (which is called "Protection") is intended to increase as much as possible this kind of trade at the expense of the other kinds.

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*The State owes the inception of this great industry to the enterprise and patriotism of the late T. S. Mort.—EDITOR.

Another part of the recognized Australian policy affects trade too. While the manufacturer is protected (see end of chapter) from the competition of oversea manufacturers who pay less wages than he and can therefore sell cheaper in an open market, he is also compelled in various ways by various States to pay high wages to his workmen. When, therefore, he tries to sell his goods outside Australia, he is handicapped by the extra expenditure in wages without getting any compensating protection, and he finds it almost impossible to sell at a profit. (There are a few exceptions to this rule—Australian agricultural machinery, for instance, sells well in South America—but they are very few.) Consequently, as already mentioned, things manufactured ready for use in Australia must mainly be sold in Australia; it is only in raw material and cheaply-produced eatables that Australian traders can compete with producers outside. When we take New South Wales by itself, the statement is not quite true, because inside Australia all manufacturers are on an equal footing, and it is therefore possible to sell local manufactures in other States without loss; but it is equally true about the oversea trade.

The following table gives such figures as are available to show how the principal products of the State are disposed of:—

TABLE I.

EXPORTS OF N.S.W. PRODUCE, 1907. (Values in £1,000s.)

		Produced	Exported	
			Inter-State	Oversea
Raw material and eatables	Wool	17,185	...	17,158
	Coal	2,922	614	893
	Metals :		(also 431	in bunkers)
	Gold	1,051	...	731
	Silver } (including	3,916	...	3,916
	Copper } ores)	728	...	728
	Wheat and Flour ...	2,943	41	1,124
	Butter	2,612	133	769
	Meats	...	109	1,074
Articles manufactured for use	Tobacco, manufactured	1,063	215	1
	Medicines	368	139	21
	Pianos	...	58	1
	Boots and Shoes ...	1,065	149	11

(Figures not given cannot be obtained from official sources.)

NOTE.—1907 was taken as a normal year: but it is not so much the actual figures that matter as the proportions, which will be seen to illustrate the statements at the beginning of the chapter.

The **import** trade is, of course, also partly inter-State and partly oversea. Inter-State imports are of the same character as inter-State exports—manufactured goods in respect of which the merchants of Melbourne, say, can compete freely with those of Sydney, and certain eatables which the climate of other States suits better than that of New South Wales. Thus in 1907 the State exported (mainly to Queensland) £149,000 worth of "apparel and attire," at the same time importing £338,000 worth of similar goods, mainly from Victoria: and, while large quantities of butter were exported to Western Australia, large quantities of potatoes were imported from Tasmania and of sugar from Queensland.

Imports from oversea consist almost entirely of manufactured goods that cannot be produced so cheaply or so satisfactorily within the State. (The word "satisfactorily" must be understood to mean "suited to the taste of the purchaser.") The only considerable imports that could be in any way classed with raw material are unmanufactured tobacco (about £200,000), tea (about £561,000), and undressed timber (about £336,000). The imports of metal manufactures and machinery, on the other hand, were valued at £3,762,000; of apparel and wearing fabrics at £6,582,000; of partly manufactured iron and steel at £911,000; and of books, paper, and stationery at £870,000. Nearly all costly luxuries are imported, because it does not pay to manufacture them locally for the small proportion of the population that likes to indulge in them.

The volume of trade varies greatly with the seasons, as must always happen when a country depends mainly on its pastoral and agricultural exports for its prosperity. But—as figures below will show—the general level of the State's trade has been lifted considerably during the last ten years by the immense development of wheat-growing and the impetus given to dairying by refrigerated transport to Europe.

TABLE II.

N.S.W. TRADE, 1899-1909. (Values in £1,000s.)

	1899	1901	1903	1905	1907	1909
Imports, Inter-State	10,868	9,368	12,792	14,939	18,596	17,147
Imports, Oversea	14,726	17,560	13,978	14,485	20,860	20,888
Exports, Inter-State	8,862	9,140	7,877	12,263	15,881	15,793
Exports, Oversea	19,583	18,211	18,941	24,519	32,894	26,045
Total External Trade	54,040	54,279	53,588	66,206	88,231	79,873
Ditto, per head of population	£40 10 5	39 13 8	37 14 11	44 15 6	56 14 11	49 3 4

(The low figures for 1903 are due to the great drought of the previous year; the figures for that year are even lower—exports 24 millions, imports 26, trade per head £35 9s. 10d. The apparent decrease between 1907 and 1909 is due almost entirely to a decrease in prices, not to a falling off in quantities).

For the distribution of New South Wales trade between countries within and outside the Empire, see Chapter XXIV.

The trade of the State is carried on almost entirely through the port of Sydney. Newcastle takes a large share of the coal-trade, and consequently gets a small import trade: and a good deal of inter-State trade of course, goes on across the borders. The following table shows the proportions with sufficient accuracy:—

TABLE III.

EXTERNAL TRADE OF N.S.W. STATIONS, 1907.

(Values in £1,000s.)

Sydney	68,611	Broken Hill (S.A. border)	5,182
Newcastle	4,192		
Wollongong	152		
Other seaports	81	Queensland border	2,785
Crossings to Victoria :			
Albury	2,911		
Moama	2,223		
Other	2,035		

THE TARIFF.

Earlier in this chapter reference was made to the policy of Protection. This policy is one of several schemes by which it is hoped to increase the population of Australia, to make it healthier all round, and to guard against the danger that in war time Australians may be deprived of the comforts, and even of some of the necessities, of life. In some countries it is believed that these advantages can be secured better in other ways: Australia has chosen this way. The gist of the policy is to levy heavy duties on certain goods imported from abroad, thus making it more expensive for Australians to buy them. This allows the local manufacturer to charge such prices for his goods as will enable him to pay high wages to his workmen and still to make a profit; thus (*a*) the workmen are well paid and can live healthy and comfortable lives, (*b*) the manufacturer is able both to live comfortably himself and to employ many men, (*c*) important industries are established in the Commonwealth, so that little inconvenience would be suffered even if in war time communication between Australia and the rest of the world were for a time severed.

It is fair to say that the policy has hitherto been carried out clumsily, and it is sometimes difficult to see why certain duties have been levied; many duties, furthermore, are levied simply in order to get revenue for the Federal Government, not for protective reasons at all; but the intention just stated is made quite clear. Take, for instance, the duties on "Textiles and Attire." Actual clothes are taxed heavily (35 to 40 per cent.) because clothes can be made in Australia, whatever the material may be; but the "piece goods," or material itself before it is cut up for garments, are taxed according to their composition—woollen goods being taxed heavily (25 to 30 per cent.) because Australia grows its own wool and can therefore manufacture the goods direct; silks and velvets being still taxed, but more lightly (10 to 15 per cent.), in order to get revenue from their importation (for a heavy duty would prevent people from importing them, and would therefore lessen revenue); cotton goods being taxed very lightly indeed (5 per cent.), and let in free if they come from Great Britain. In the same way simple machinery, which can be made in Australia, pays a heavy tax when imported, while complicated machinery comes in with little or no duty to pay.

The amount paid specially to ensure protection may be roughly estimated from the statistics of New South

Wales. Before Federation the State policy was one of free trade, duties being levied almost entirely with a view of obtaining revenue. During the last seven years of this *régime* the average Customs taxation per head of the State's population was £1 3s 7d. The change to protection was made when the Federal Parliament took over the control of the Customs: and for the next seven years (omitting the year in which the change was made) the average Customs taxation has been £1 18s 2d. Against these figures should be put the following, relating to the factories of the State:—

	Average, 1894-1900	Average, 1902-8
Number of factories	2,911	3,850
Number of employees	52,108	75,070
Value of machinery and plant ...	£5,414,121	£8,127,493
Value of production ... ... (official estimate)	£8,079,000	£11,307,000

Religion.

At the census of 1901—the last occasion on which definite figures were obtained—98 per cent. of the State's population professed some form of Christianity; of these about 47 per cent. were Anglicans, 26 per cent. Roman Catholics, while the Presbyterian and Methodist churches accounted for about 10 per cent. each. These figures should be set side by side with those of the "religious census" of 1904, which took account only of attendances at some church on a particular Sunday, and with a set of figures obtained from the educational statistics of 1908, in which attendance at the definitely denominational schools is blended with the ascertained religion of the parents of State school children.

TABLE IV.

RELIGIONS.

	1901	1904	1908
	per cent	per cent	per cent
Anglican	47	24·3	42·7
Roman Catholic ...	26	28·3	27·4
Methodist	10	23·6	11
Presbyterian	10	13·1	9·3
Other	7	10·7	9·6

The Anglican Church is governed by an Archbishop (who is also Primate of Australia) and five Bishops, with sees at Sydney, Newcastle, Goulburn, Armidale, Bathurst, and Hay. The diocese connected with Armidale is called "Grafton and Armidale," and that connected with Hay is called "Riverina."

The Roman Catholic Church in Australia has a Cardinal-Archbishop (with a Coadjutor Bishop) at Sydney, and six other Bishops with sees at Maitland, Goulburn, Bathurst, Armidale, Lismore, and Wilcannia.

The Anglican, Roman Catholic and Presbyterian Churches have Colleges in connection with the University of Sydney, and the Wesleyan Methodists are likely soon to follow their example. All these churches have also large secondary schools under their care, and the Roman Catholics support their own primary school system quite apart from the State.

SOCIAL CONDITION.

In Chapter V. was given a table showing the occupations of the "breadwinners" among the population, which for convenience sake is repeated here: do not forget that 58 per cent. of the population are classed as "dependent," and that the table refers only to the remaining 42 per cent.

Engaged in Production	46·75 per cent.
,, ,, Transport	7·75 ,, ,,
,, ,, Commerce	14 ,, ,,
,, ,, Professions	7·25 ,, ,,
,, ,, Domestic Services ...	13 ,, ,,
,, ,, Other Occupations ...	9·5 ,, ,,
Independent	1·75 ,, ,,

("Domestic Services" does not include persons employed in household duties for which no wages are paid—*e.g.*, wives and daughters of breadwinners

The proportion of commercial breadwinners is unusually high: in Britain and Germany it is only about 8 per cent. Of course none of these percentages is quite accurate nowadays; when the census was taken in 1901, New South Wales was still practically a free-trade colony, and the Federal tariff has greatly increased the number of factories—but it is probable that these have been fed with employees mainly from the class formerly occupied in domestic services, or from the ranks of the "dependents."

For the welfare of any State it is important that its citizens should be employed wisely—*i.e.*, as many as possible in producing something, as few as possible in the accessory businesses of commerce and the professions. New South Wales has a long way to go before this stage is reached. But it is more than important—it is indispensable for the State's welfare, that its citizens should live healthy and comfortable lives. And in this respect New South Wales compares favourably with most countries in the world.

As regards health, the death-rate per thousand has steadily decreased from 17 in the years 1860-9 to 10 in the years 1900-9, and in 1909 was 9.75, lower than ever before. Similarly the death-rate among babies has decreased from 120 per thousand in 1880-9 to 89.6 in 1900-9, and in 1909 was 74.28—also the lowest on record. These figures are partly due to the increase of scientific knowledge and its applications—the death-rate of Sydney, for instance, began to fall considerably when once a modern sewerage system was installed—but bear witness also to a great increase in the prosperity of the people.

With regard to comfort, there are a great many kinds of evidence, *e.g.*,

Housing.—91 per cent. of the population live in private houses; of these more than two-thirds live in houses of from five to ten rooms. More than half the dwellings are built of wood, but this is as much the result of climatic conditions as of the cheap material.

Form of Employment.—About 54,000 employers give work to about 362,000 wage-earners: 82,000 persons are classified as working on their own account, and 24,000 as relatives assisting but not wage-earning. About 25,000 persons returned themselves in 1901 as Unemployed; of these, however, comparatively few had been long out of work, and the proportion of genuinely unemployed persons (omitting the sick and the aged, who are otherwise provided for) to the population at large is now infinitesimal. Child labour—*i.e.*, that of persons under fifteen years of age—accounts for about 2 per cent. of the whole "bread-winning" labour; this is due to the excessive use of children in dairying.

Wages.—In the last fifteen years wages have risen all round: this is due partly to the effect of Arbitration Courts and Wages Boards—as where blacksmiths' and painters' wages have risen from 8/- to 10/- a day—and partly to the increased demand for labour—as where farm labourers' wages have risen from 12/6 to 20/- per week, though neither Courts nor Boards govern this occupation. On the other hand, the cost of living is said to have gone up considerably during the same period.

Savings.—Some indication of the savings which residents in the State have been able to make can be gathered from figures supplied by the banks. In hard times people pay in little, and borrow what they can: in "boom" times they borrow a great deal and pay in a great deal: in times of real prosperity they pay in a great deal and borrow little. Thus:—

In 1890, 1,122,000 people borrowed £43,000,000, and paid in £35,460,000.

In 1902, 1,408,000 people borrowed £34,886,000, and paid in £32,578,000.

In 1908, 1,605,000 people borrowed £39,213,000, and paid in £43,910,000.

Or to take averages,—

In 1890, the average man borrowed £38·3, and paid in £31·6.
In 1902, the average man borrowed £24·6, and paid in £23·5.
In 1908, the average man borrowed £24·4, and paid in £27·3.

These figures, coming from the large private banks, probably refer in the main to the finances of the employing and landowning classes. The savings of the wage-earning classes are better gauged by the returns of the Savings Banks, of which there are two in the State, one controlled by the State Government directly, the other by trustees whom the Government nominates but does not otherwise interfere with.

Year	Amount of Deposits	Average Amount					
		per Depositor			per head of Population		
	£	£	s	d	£	s	d
1890	4,730,469	32	17	10	4	4	4
1902	12,425,464	38	8	10	8	16	6
1908	18,805,280	43	11	2	11	14	4

In 1903, the year following the great drought, depositors withdrew £80,000 more than they put in:

in 1907, the year following an exceptionally good season, they put in £2,210,000 more than they withdrew. In 1909 more than 88 per cent. of the depositors had a balance of not exceeding £100.

Another gauge of the amount saved by the citizens of a State is the amount spent on life-insurance. This cannot be estimated for New South Wales alone, as separate figures are not published: but in Australia the amount assured increased from £103,000,000 in 1902 to £128,000,000 in 1908—that is to say, the amount assured per head of population increased from about £26 to about £30.

One more gauge of general prosperity is worth considering. In the eighties, out of every hundred people who died 11 had property enough to make wills about. In the nineties, the proportion rose to 13 or 14. In the years 1905-7 the proportion was 19 per hundred. This takes account of the deaths of women and children; if we consider adult males only, the proportions range from 34.6 per cent. in the eighties to 46.2 in 1905-7.

CHAPTER XXII.—GOVERNMENT AND TAXATION.

(A. W. JOSE.)

New South Wales, like all the other Australian States, has a double form of government. Certain important matters, regarding which it is better to deal with Australia as a whole, have been handed over to a Federal Parliament and Government; these will be dealt with in Chapter XXIV.

In all matters not so disposed of New South Wales is self-governing, and the mechanism of its government is of the same pattern as that of all self-governing colonies within the British Empire. Because it belongs to the Empire, and is therefore in the last resort subject to the central Imperial Government in London, the official head of the State Government is a Governor appointed by the Crown, usually for five years. All acts of government are done in his name, and all laws must be signed by him before they become operative.

The real governing body, whose advice the Governor is in most cases bound to accept, is a committee of members of Parliament called the Cabinet; their leader and chooser, the Premier, is himself the chosen head of the biggest party in the Legislative Assembly, which—though often called the "Lower House"—is the more important of the two Houses of Parliament. To elect its members the whole State is divided into ninety districts (called "electorates" or "constituencies"), and the adults in each district elect one man to be their representative. The second House—the Legislative Council—is made up of members appointed by "the Governor in Council" (which means that the Cabinet advises the appointment, and the Governor takes the advice): the Government of the day is thus able always to secure a majority in that House too, if there is any likelihood of a serious quarrel between the two Houses.

Going further into details, the Cabinet (officially called the Executive Council) is a body of eight or nine men, each of whom is Minister for some Department of the Public Service; sometimes one or two more are added, under the title of "Minister without Portfolio." At present there are eight heads of Departments, a

Vice-President of the Council, and one Minister without portfolio. The Legislative Assembly, as already said, has ninety members, elected for not more than three years at a time. They must themselves be electors of the State—which means that they must be twenty-one years old, British subjects, inhabitants of the State for at least a year and of one particular district for at least three months. They are paid £300 a year. The Legislative Council's numbers are not fixed, though there is a feeling that it should usually be not much more than half the size of the Assembly: at present it has 56 members. They must be adult British subjects, and not Government contractors. They are appointed for life, and are not paid.

The Governor appoints the President of the Council: the Assembly chooses its own Speaker.

Laws must be passed by a majority in both Houses, and then signed by the Governor. Laws on certain subjects which would affect British subjects outside Australia, or might lead to Imperial difficulties with foreign powers, are not signed at once by the Governor, but ''reserved'' and sent to London to be considered by the Imperial Government.

Subject to these laws, the Cabinet administers the Government of the State, each Minister, as aforesaid, dealing directly with one Department, which may have many branches. Thus the Treasurer, besides managing the State's finances, administers the Acts that concern shipping and navigation, and is nominal head of the State railways; while the Minister for Public Instruction, whose proper charge is education, also looks after the observance of the Early Closing and Factories Acts. The Departments of Lands, Mines, Public Works, and

Agriculture, have their duties defined by their titles. The Attorney-General and Solicitor-General (when there is one) deal with legal matters; and the Chief Secretary—who used, before Federation, to be the most important member of the Ministry, and dealt with the State's relations to other States, the Empire, and foreign nations—now looks after the elections, the police, the aborigines, and a host of minor concerns.

Various Boards of Commissions have taken over from Ministers the actual control of many State enterprises, although in matters of big policy they are still under Ministerial control. The chief of these is the Board of Railway Commissioners, which controls all the State railways and tramways, when they are once constructed. (The Chief Commissioner is supreme among them; two Assistant Commissioners, one for Railways and one for Tramways, complete the Board). The Metropolitan Board of Water-Supply and the Sydney Harbour Trust are next in importance; others deal with the public health, fisheries, fire brigades, &c.; and the Public Service Board is charged with the duty of selecting and supervising Government officials. Most of these Boards are appointed by the Governor in Council: to some, which deal with matters affecting particular towns—*e.g*, the Sydney Water Supply—, a few members are elected by representatives of those towns.

LOCAL GOVERNMENT.

Up to 1906 more than ninety-nine hundredths of the State were in everything directly under the State Government: the remaining fragment consisted of 191 boroughs and municipal districts which administered their own local affairs at their own expense, with subsidies from the State Treasury. In 1905-6 the Eastern and Central Divisions, outside the existing municipalities, were divided up into 134 shires, each to be governed by a locally elected Council. The revenues of these bodies are derived from (*a*) rates on shire lands, the first of which must be at least 1d. in the £ on the land's unimproved value, (*b*) subsidies (officially called "endowment") from the State Treasury, varying according to the shire's area, population, and wealth. Under certain restrictions the Councils may borrow. Their work is to maintain the roads, control the traffic, and administer certain Acts within the shire boundaries: if they choose to ask, they may also acquire the control of markets, gas and water supplies, ferries, theatres, libraries, and many other institutions useful to the local population.

It is interesting to compare the division of responsibilities made in New South Wales with that existing in English towns. In the following table "S.G." means "controlled by the State Government; "L.G." means controlled by local authorities; "P.", provided by private enterprise.

	N.S.W.	England
Road Maintenance ...	L.G.	L.G.
Police	S.G.	L.G.
Education	S.G.	L.G. (under State supervision
Water Supply	L.G.	P. or L.G.
Tramways	S.G.	L.G. or P.
Gas or Electric Lighting ...	P. or L.G.	P. or L.G.
Fire Brigades	S.G.	L.G.
Railways	S.G.	P.
Harbour Works	S.G.	L.G. or P.

Note how much more centralized is the New South Wales method, concentrating so much power in the State Government's hands.

Legislation.

Of late years the State Parliament has busied itself chiefly with law-making for three great objects: (*a*) fully using the land, and settling on it an industrious population, (*b*) improving the condition and efficiency of employees in every trade or manufacture, (*c*) guarding the people of the State against the more obvious evils which would prevent them from living a healthy, happy life.

Under (*a*) come Acts for re-purchasing fertile lands from pastoralists, dividing them into suitable farms, and selling them to men able and likely to cultivate them properly. It has also been made easier to settle on Crown lands, and harder to own land without using it. Under (*b*) we may place the Acts for regulating wages and conditions of labour by means of wages boards, on which representatives of employer and employee meet under the presidency of an impartial umpire; Acts for regulating the sanitary condition of factories, for minimizing night-work and child-labour, and so forth; and measures, financial and other, to improve and extend the existing system of technical education. In (*c*) are included Acts that lessen the opportunities for drunkenness and increase the safeguards against vice. It is sometimes made a complaint that all these regulations and restrictions hamper the free course of commerce and industry. But commerce and industry, though most valuable assets to a State, are merely means to an end: the final aim of trader and worker and lawmaker alike, in a sound State, must be the production of the greatest possible number of healthy and able citizens. Nothing else matters in comparison.

TAXATION.

The administration of a great State costs much money, partly to pay the salaries of the administrators, partly to construct and maintain the public works—railways and tramways, roads and bridges, housing for officials, and so forth. This money is raised in five ways:—

(*a*) By taxation.
(*b*) By grants from the Commonwealth.
(*c*) By payments for services rendered.
(*d*) By sales of Crown land.
(*e*) By borrowing.

For the construction of railways and roads and buildings which ought to last many years, it is considered unfair to make one year's taxpayers contribute the whole amount; the money is therefore either borrowed or taken from the proceeds of land sales. If the work, when done, will earn money—as railways do by charging for passengers and freight, for instance—the money for first construction is borrowed, and the earnings are used to pay interest on the loans, as well as to provide working and maintenance expenses and money for repairs. The State, that is, does exactly what a good business man would do. If, however, the works will not earn money directly—like roads or Government offices, for whose use no charge is made—the cost is paid out of land sales money (called the Public Works Fund); the State used to own so much land, which was a permanent possession—it substitutes for that roads or offices or other works which will also be fairly permanent. Repairs to such works, and their maintenance, must be paid for otherwise.

"Payments for services rendered" means charges like those just mentioned in regard to the railways; there are many other sorts, such as fees for legal work done by public servants, rents paid by shipping companies for State-owned wharves, rent of Crown lands, &c. The money received in this way goes to pay the expenses of keeping up the service.

A very large item in the State's expenditure is the interest on borrowed money. Part of this is paid, as already stated, out of the earnings of revenue-producing works. But in former times Governments were not so strict about using borrowed money only for such works; and a great deal of the State debt is due on works which produce no revenue. The interest on this part of the debt has to be met from other sources. There is also a great deal of State expenditure which brings in no money return at all, and funds have to be found for this—education, for instance, and the police, and grants to hospitals and Schools of Arts. Thus it becomes necessary to tax the citizens—to make them pay, as far as possible according to their ability, without reference to the exact amount of benefit each derives from police or school or hospital. The principal tax levied in Australia is a Customs duty on nearly all imported articles: this is fixed by the Federal Parliament, and produces so much more than the Commonwealth wants for its own enterprises that a large proportion of the proceeds is paid over to the States. Besides this, the State Government levies taxes of its own, of which the principal are Income tax, Stamp duties, Probate and Succession duties, and a Land tax on lands outside the Local Government area.

In making up the State's accounts a very useful distinction is now made between the Government's proper work and the businesses which it carries on. Consequently it is possible to show how the State gets and spends its money quite clearly, in the following form:—

BUSINESS UNDERTAKINGS.

(*i.e.*, RAILWAYS, HARBOUR TRUST, SYDNEY AND NEWCASTLE WATER SUPPLY).

Receipts during 1908-9	...		£6,998,180
Expenses ,, ,,	Working ...	£4,145,383	
	Interest ...	2,360,999	
			6,506,382
Profit ...			£491,798

GOVERNMENTAL RECEIPTS, 1908-9.

Returned by the Commonwealth ...	£3,356,158
Proceeds of State taxes ...	907,249
Profit on businesses ...	491,798
Land sales ...	998,532
Land rents ...	779,470
Payments for services rendered ...	310,882
Other miscellaneous ...	274,600
	£7,118,689

GOVERNMENTAL EXPENDITURE, 1908-9.

Interest on rest of Public Debt ...	£755,058	
Education ...	1,088,328	
Pensions (including Old Age Pensions) ...	816,655	
Grants for Local Government ...	205,773	
Grants to Agricultural Societies ...	18,096	
Hospitals, Charities, and Lunacy ...	900,520	
Other Governmental Expenses ...	2,509,289	
		£5,897,434
Transferred to Public Works Fund ...		809,561
Transferred to Closer Settlement Fund (see p. 32) ...		1,000,000
Sinking Fund Instalments (see below) ...		478,791
		£8,185,786

These accounts seem to show a large deficit. That is because the payment to the Closer Settlement Fund was really made out of a big credit balance brought over from the year before.

The work of the various Town- and Shire-Councils is paid for, as stated already, partly from the Government subsidy, partly out of rates levied by the Councils themselves. The latest available figures are as follows :—

REVENUE, for year, to Feb., 1908 :—		
Municipalities, general rate	£524,148	
,, special rates	337,514	
,, State grants	71,206	
,, services rendered	162,982	
		£1,095,850
Shires, general rate	287,635	
,, State grants	235,794	
,, for services rendered, &c.	12,230	
		535,659
EXPENDITURE :—		
Municipalities, administration	£99,356	
,, works, &c.	835,146	
,, interest and sinking funds	154,945	
,, miscellaneous	82,709	
		£1,172,156
Shires, administration	100,435	
,, works, &c.	255,204	
,, miscellaneous	29,896	
		385,605

THE PUBLIC DEBT.

The amounts borrowed from time to time for constructing public works and other purposes, less repayments of early loans, constitute the Public Debt of the State. It stands now at over £90,000,000, of which £44,000,000 was borrowed before 1890, and the rest as follows :—

1891—5	£11,684,000
1896—1900	8,832,000
1901—5	16,298,000
1906—9	9,493,000

In early days this borrowed money was spent without much consideration on all sorts of public works, and even on small repairs and quite temporary and unproductive things. Nowadays great care is taken to avoid such expenditure out of loans. Compare, for instance, the two following sets of figures:—

	Loan Expenditure on	
	Reproductive works	Other works
1900	£1,679,223 or 70%	£721,720 or 30%
1909	£2,859,317 or 98½%	£47,190 or 1½%

The total debt of £90,000,000 has been spent as follows:—

Business undertakings ...	£70,253,637	Productive, 79%
Land—resumptions in Sydney ...	1,170,109	
Developmental works* ...	7,856,419	8¾%
Public buildings	4,463,601	12¼%
Buildings and works handed over to the Commonwealth ...	3,430,647	
Other non-productive expenditure	3,133,006	

The money thus expended has been borrowed mainly in London, from which nearly three-fourths of it has come; the interest payable on it averages about 3½ per cent. As the principal becomes payable, more money is usually borrowed to replace it; this can often be done at a lower rate of interest than the original one, so that a good deal is saved in that way. Nearly ten millions are due for repayment in 1912; besides about two millions borrowed locally for short periods on what are called "Treasury Bills," and about a million and a quarter temporarily borrowed to pay off deficits of past

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*Developmental works are such as help in developing the State's resources, though not earning money directly—*e.g.*, roads, bridges, water-storage, deepening river-channels, &c.

years. Towards these latter sums the Government puts by each year at least £350,000, called the "Sinking Fund": in 1908-9, as we have seen, nearly £480,000 was so put by.

You must note that the profit on the State's businesses went a long way towards paying the interest on the rest of the debt: in 1907-8 it paid the whole and more. At the same time the State does not try to make any great profit. When there is one, it is spent on improving the **plant**, or the charges made to the public are reduced.

Besides what the State owes, various municipalities have been allowed to borrow for works, &c., on the security of their rates. Their loans have chiefly been raised in the State, at an average interest of nearly 4 per cent.; while loans for purposes of water-supply are mostly made by the State Government at 4 per cent. The figures follow:—

Water Loans to Country Municipalities ...	£726,898
Other outstanding loans, country ...	629,445
Loans, Sydney and suburbs	2,676,320

The State's loans are provided for by annual payments which include both interest and sinking fund: for the rest there are sinking funds amounting to less than £200,000.

CHAPTER XXIII.—CONDITION OF THE PEOPLE.

(A. W. JOSE.)

If you have carefully read Chapters XIV. and XVI., you will understand some of the reasons why New South Wales is not very thickly populated. It is the most populous, and one of the most fertile, of the Australian States; by the end of 1910 it will have nearly 1,700,000 inhabitants; but even so the density is only about 5½ people to the square mile, as against Victoria's 14 and New Zealand's 9¾. And those figures look very tiny when compared to the United States' 29, the German Empire's 297, and the United Kingdom's 367.

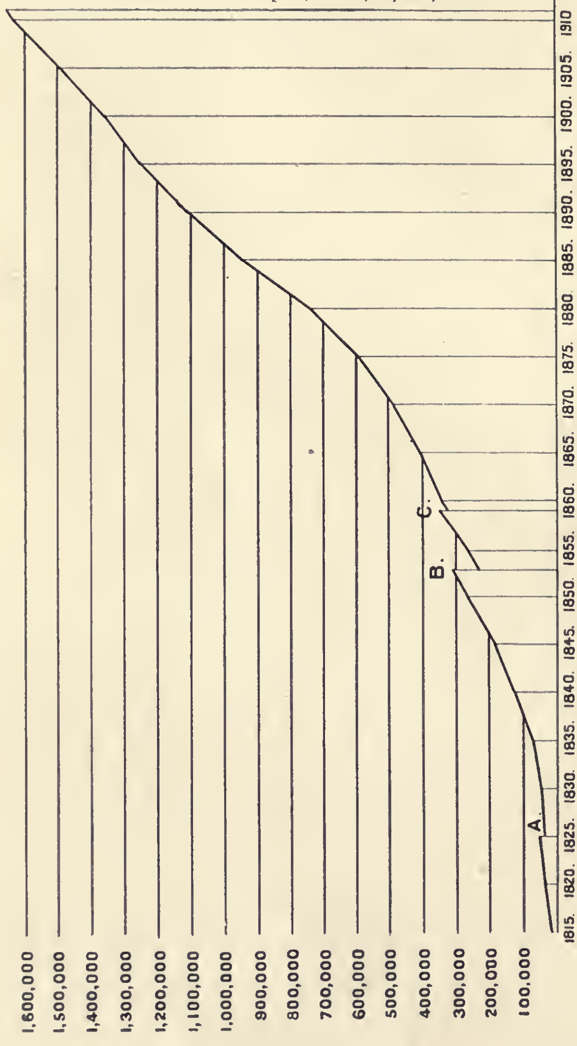
The truth is, of course, that the people of New South Wales live in a number of bigger or smaller patches, each separated from the others by almost empty territory. The biggest patch—many think it too small for the number of its population—is centred on the chief town, Sydney, which (with its suburbs) holds quite a third of the total; two other large towns—Newcastle and Broken Hill—account for another 100,000; about 124,000 more live in towns of over 5,000 inhabitants each. That is to say, nearly half the population is concentrated in 19 small patches and employed in townsfolks' occupations. And this process of concentration has been going on for the last fifty years at least, practically ever since the land-legislation of Sir John Robertson described at the end of Chapter III. Only within the last few years has anything practical been done to disperse settlement more evenly over the State, and it is still too early to expect easily demonstrable results.

One interesting point about the growth of Sydney is made clear in the following table:—

Inhabitants of	Per cent.	Nationality		
		Australian	British	Foreign
Sydney and suburbs ...	35¾	33½	47	44½
Other municipalities ...	27¾	27¾	26	24¾
Rural districts	36½	38¾	27	30¾
	100	100	100	100

Now the "other municipalities" are often large country areas with a small township at their centre, and so include among their population many people who are, properly speaking, residents of "rural districts." Leaving them out of account, therefore, as equally balanced between townsfolk and country-folk, we see that the Australian born, by a small majority, prefers the country to the towns; the British immigrant strongly favours Sydney; the foreign immigrant also prefers Sydney, but if he is not a factory-hand or commercial man is likely to be a farmer. These figures, however, are based upon the census of 1901, the last quite trustworthy statement we have; and great efforts have been made since then to bring out from England farm-labourers and men likely to settle on the land. So, when the results of the 1911 census are known, we may find that the British immigrant is less of a townsman, and that Sydney has begun to swallow up fewer, proportionately, of the State's population.

The diagram on page 334 shows graphically how and how much the State has grown in population since 1860. Remember the "Excess of Births" means the surplus left every year after subtracting from the number of births the number of people who died. Remember, too, that one way of increasing the population—a way which is made more efficient every year—is to take much greater care of very young children. Between 1860 and 1870 about ten per cent. of our children died before they were a year old. In the prosperous but careless years between 1875 and 1890 twelve and thirteen per cent. used to die; while since 1903 the number has fallen to seven and eight per cent. In 1908, indeed, in spite of the great increase in



Census of 3rd April, 1911, 1,648,448

Fig. 107. CURVE OF POPULATION INCREASE IN NEW SOUTH WALES.
A. Tasmania Separated B. Victoria Separated C. Queensland Separated

population, fewer babies died than in any year from 1881 to 1903.

Three other points about the State's population-records are worth notice—the proportion between the sexes, the birthplaces, and the probable distribution in the future.

In the early days, as might be expected, men far outnumbered women in New South Wales. To the end of the "exploration period" (Chapter II.) about 75 out of every hundred were men. Governor Bourke's scheme of assisted immigration so altered that that in 1846 the proportion was only 60 to 40. From that time on the proportion has slowly approached equality; but even in 1901 107 out of every 200 inhabitants were males. This preponderance of males is, of course, characteristic of young nations, and is found in all the Australian States except Victoria, where the women are as numerous as the men; it occurs also in New Zealand, India, Canada, and the United States; but in nearly all European countries the women are in the majority, and in England 104 out of every 200 are women.

In 1901 out of every 100 residents in the State 72 were born in it, 8 in other Australian States, and 16 in the United Kingdom. Among the rest—say 40,000 in all—there were 8,000 Germans, 4,500 Danes and Scandinavians, 2,000 Frenchmen, 3,000 Americans, 9,000 Chinese, and 3,000 Indians. To put it another way, out of every 1,000 people 988 were "white"—*i.e.*, of British, American, or European birth; the other twelve were "coloured," either Asiatics or Polynesians. Since 1901 the proportion of British-born (including Australasians) has increased and the "coloured" population has diminished.

As regards distribution, we have already noticed that the State's recent encouragement of immigration and of settlers on the land has begun to diminish the over-congestion of the towns. Since 1904 immigrants have been arriving at the rate of about 10,000 a year (see diagram above), mainly from the United Kingdom and New Zealand. In 1909, for instance, nine thousand persons came from the United Kingdom., over seven thousand from New Zealand, and about twelve hundred from foreign countries; five thousand of these merely passed through the State on their way to other parts of Australia, so that the net gain was over twelve thousand.

EDUCATION AND RELIGION.

Since without the study of books and newspapers it is very difficult to become a sensible citizen or even a good workman at any kind of trade, it is now agreed in nearly all countries that the inhabitants should receive at least a simple education, under the State's direction and, partly if not wholly at its expense. In the early years of this State's history the establishment and supervision of schools was left almost entirely to the various religious denominations, while the Government contributed part of the cost: but in 1880 an Act was passed which abolished these contributions and established State schools (called in New South Wales "Public Schools") in all centres of population. These are supervised entirely by Government inspectors; their cost was met mainly from public funds, but at first the parents of children under instruction paid 3d. a week towards it. Twenty-six years later, however, this payment was abolished, and education in the simpler or "primary" State schools is now free to every child in New South Wales.

All children between the ages of 6 and 14 must attend some school or have definite private instruction at home. Those going to school must attend for at least seventy days in each half-year. Those who live some distance from a school are carried free on the State railways, and where there are no railways the Government often pays for a conveyance to take children to the nearest school. Where this is not done, "half-time" schools are established, or teachers are sent to the childrens' homes, or in a few cases small private schools get a contribution from public funds. But year by year the Government is doing away with these contrivances, preferring to keep up big schools in a central situation and to bring the outback children to them.

As a result of these attempts to give every child in the State some kind of education, the number of people unable to read or write is rapidly diminishing. In 1881 26 per cent. were unable to read, in 1901 only 18.6 per cent. And when you deduct children under five years old—who can hardly be expected to read—and consider the children of school age, whom the State's education system is intended to reach, the improvement is much greater; in 1881 64.5 per cent. of them could read and write, while in 1901 76.6 could.

Apart from the half-time and subsidized schools mentioned above—which are merely temporary stopgaps—the system of State education comprises:—

i. **Primary** Schools, often beginning with Kindergarten instruction:

ii. **Superior** Schools, in which a couple of classes are added at the top to teach secondary subjects:

iii. **High** Schools:

iv. The **University** of Sydney, subsidized but not controlled by the State:

(These four make up a complete course of instruction, from Kindergarten to the University degree):

v. **Teachers' Training** College:

vi. **Technical** Schools:

vii. **Industrial** Schools:

viii. In the bigger country towns **District** Schools—Primary Schools with High School classes added, which are also used for training teachers.

The State also subsidizes the Sydney Grammar School—the most important secondary school in New South Wales—and a school for the Deaf, Dumb, and Blind. And there are numbers of private Secondary Schools scattered throughout the cities and townships of the State; in and about Sydney these are mostly denominational, in the smaller towns they are usually private property.

In connection with the Primary Schools the Department carries on Savings Banks, Cadet Corps, and (for the city and suburban schools) Rural Camp Schools, at which town-bred boys are introduced to country life, with the result of inducing many of them to go on the land. State Technical instruction includes, besides the Central College at Sydney (with its 162 classes) and the 574 suburban and country classes, the instruction of a certain number of primary school pupils in science, cookery, shorthand, elocution, typewriting, dressmaking, and elementary agriculture.

The University of Sydney, established in 1852, gets a substantial part of its revenue (in 1909 £15,000 out of £54,000) from public funds. It is a teaching as well as an examining body, degrees being granted only to those who have attended lectures. It has faculties of Arts, Medicine, Law, and Science, including Engineering, besides attached schools of Military Studies, Commerce, Dental Surgery, and Agriculture and Veterinary Science. Its staff comprises 18 Professors, 5 Assistant Professors, and 78 lecturers and demonstrators: 1,294 students attended lectures during 1909, and 237 obtained degrees. The governing body is called the Senate, and consists of 16 members, at present elected for life by the graduates of the University, and four Professors nominated by the four Faculties.

The University also exercises an informal but substantial control over secondary education within the State by means of the Senior and Junior Public Examinations, conducted by members of the teaching staff; parents and the public are apt to gauge the progress of the schools by the results of these examinations, for which 166 Senior and 1,201 Junior candidates sat in 1909.

Besides all these teaching institutions, the State Department of Education is connected with the Sydney Public Library, the Observatory, the National Art Gallery, the Australian Museum, and 409 country Institutes (generally called "Schools of Arts," but are mostly libraries with a small members' fee, to which billiard-rooms and other means of amusement are attached). The Public Library, founded in 1869. contains about 148,000 volumes; attached to it is the Mitchell Library, containing nearly 61,000 volumes, besides numerous valuable paintings and manuscripts (mainly unique documents of early

Australian history), which was given to the State by its originator, the late Mr. David S. Mitchell, together with an endowment of £70,000 for its upkeep and increase. The National Art Gallery in the Domain, Sydney, contains paintings and statuary of great value, and the finest collection of water-colours outside England. The value placed on these and similar institutions by the people is shown by the fact that in one year (1909) 181,000 persons visited the Library, 273,000 the Gallery, 214,000 the Australian Museum, about 100,000 the Sydney Technological Museum, and about 122,000 the five smaller Technological Museums in country towns.

The following table, compiled from the records of 1909, shows roughly the careers upon which pupils enter when they leave the higher classes of State schools:—

TABLE I.

	Boys		Girls	
	City (1 532)	Country (919)	City (1,176)	Country (762)
	per cent.	per cent.	per cent.	per cent.
To the University ...	3·2	1·3	...	·26
To technical classes ...	5·5	1·2	...	...
Teachers	3·07	8·05	7·14	11·7
Clerks and typists ...	10·83	10·0	5·4	3·0
Commercial life (including shop assistants)	23·3	13·17	7·3	3·5
Trades (including labourers)	33·9	35·7	...	...
Tailoring and dressmaking...	...	...	11·65	7·22
To the land	4·2	14·6	...	...
Domestic duties (at home)...	...	...	59·4	65·7
Domestic duties (in service)	...	...	·17	3·15
To the Public Service (except teachers)	7·6	10·4	·76	·13
Other occupations ...	8·4	5·58	8·18	5·34

(The numbers immediately under the words "City," "Country," show the number of cases investigated. All these pupils had received some secondary education.)

The chief statistical facts about education in the State are given below:—

TABLE II.

TEACHING INSTITUTIONS, 1909.

	Number of			Expenditure £	Sources of Income
	Instit.	Teachers	Students		
The University	1	99	1,274	69,494	State, £15,845. Benefactors, £30,630. Fees, £22,459.
High Schools	5	41	1,035	10,204	Fees, £3,706: rest from State.
Public Schools (*a*)	2,731	6,176	273,074	919,052	from State.
Provisional Schools (*b*)	344			81,437	
Teachers' Training College	1	295	298	16,746	
Private Denominational Schools (*c*)	456	2,393	48,496		
Private Proprietary Schools (*c*)	333	1,240	9,865		
Sydney Technical College	1	99	5,138	73,136	Fees, £11,684: rest from State.
Other Technical Classes	702	193	10,332		

(*a*) Including Superior, District, and Primary Schools.

(*b*) Including Half-Time, Evening, and Subsidized Schools and House-to-House teaching.

TABLE III.

STATE EXPENDITURE ON EDUCATIONAL MATTERS.

University Subsidy	£15,425	
State Schools, other than Technical ...	1,010,693	
Technical Schools and Classes	50,498	
Scholarships and Bursaries	5,436	
Administration	46,490	
Training of Teachers	19,906	
		£1,148,448
Public Library	9,828	
Observatory	1,816	
National Art Gallery	3,026	
Australian Museum	8,977	
Technological Museums	5,116	
Reformatories, &c.	18,654	
Subsidies to Schools of Arts	11,010	
		58,428
Total expenditure for year, excluding a few items unlikely to recur		£1,206,876

CHAPTER XXIV.—IMPERIAL AND FOREIGN RELATIONS.

(A. W. JOSE.)

Having thus studied, as fully as possible in so small a book, the actual facts about New South Wales and its people—the physical surroundings of their life, their methods of government, the uses to which they put themselves and their country—we must end by considering how they and it affect the world outside. That is, probably, the most important question to be answered about any man or body of men—what difference it makes to the world at large that he or they exist and work in it.

For reasons more fully explained in Chapter II., the first civilised colonizers of Australia happened to be of British blood—of a race, that is, that dominates but does not easily blend with other races. and of a nation which, while the colonizing was going on, was strong enough in Europe to claim ownership of the whole Australian continent. Consequently the whole of this vacant area has become an isolated stronghold of the white race and of the British Empire. Up to the present it has been free both from the strife of warring nationalities which has so often torn Europe in pieces, and from the even more dangerous social and industrial competition between races with differing standards of healthy living. From Fremantle to Sydney, from Cape Otway to Cape York, the same ideas of government, the same methods, the same moral and social standards, prevail unchallenged. There is no other similar area of the earth's surface—nearly three million square miles—of which this can be said: for Brazil, Canada, China, and Russia-in-Asia are the only other large areas under a single government, and in all these there are distinct races with differing ideals living under the one flag.

But this unity has only been maintained hitherto because Britain has been strong enough to prevent intrusion, and has felt it her duty to do so. If the British people in the home islands, who pay for the upkeep of the strongest navy in the world, became unable or unwilling to keep that navy invincible, any fairly strong foreign nation could annex a great part of Australia without the slightest trouble. For this great vacant area, whose first importance to the world lay in its being vacant, is still far too empty for safety: it can never be unassailably British until its inhabitants are able to defend it themselves against attack. Nearly all the big nations are looking for vacant land, and it would be easy to find an excuse for annexing any spare block that its owners or inhabitants cannot hold by force if necessary. For this reason the two most vital questions of Australian policy are the immigration question—how inhabitants are to be procured for the great vacant spaces—and the defence question—how they, and those already here, are to be best trained to resist a foreign invasion.

From the political point of view, therefore, Australia's relation to foreign nations is that of a mainly empty country to people longing to fill it with their own friends: her relation to the Empire is that (*a*) of a great estate awaiting development to the people who may find useful work in developing it, (*b*) of a valuable but badly guarded possession, a cause of great anxiety to the Governments who are responsible for keeping it safe.

All this, which has been just said about Australia as a whole, of course applies to New South Wales; but in this regard New South Wales cannot be treated as a separate State or part of the continent. Consequently those sections of its government which are concerned with defence and immigration, as well as many others which concern Australia as a whole rather than any single State, have been handed over to a single Government to deal with. How and why this was done you will read in histories; in this geography we can only note the facts. Side by side with the Governments and Parliaments of the six States there is another Government and Parliament chosen from all the six indiscriminately, called the "Federal" Government and the "Federal" Parliament; these bodies rule all Australia—called for the occasion the "Commonwealth"—in respect of three kinds of subjects:

i. Australian relations with the world outside—defence, external commerce, Customs duties, immigration and emigration;

ii. Relations between the States, and matters in which several States are jointly concerned;

iii. Matters about which there is no particular reason why different States should have different laws—marriages, banking and insurance, post and telegraphs, various commercial laws, old age pensions, etc.

Two exceptions to these general rules must be specially noted. In the first place, while the Federal Constitution gives the Federal Parliament power to deal with immigration and emigration, that power is not much used. Federal law decides what classes of people shall not be allowed to enter Australia, and lays down certain conditions on which others shall be allowed to enter: but the separate States do practically the whole work of bringing immigrants out. This is because the State authorities still control the lands of the States; and the sort of immigrants Australia wants is the sort that will go on the land, either as farmers or farm-labourers. Until, therefore, the Commonwealth acquired land of its own, apart from that controlled by the States, it could not do much actively to encourage immigration, beyond advertising in Britain the advantages of coming to Australia. Now that the Federal Government has taken over the Northern Territory, it can itself begin to bring out immigrants, if it chooses.

In the second place, one would think that railway travelling was a matter in which several States were jointly concerned, just as much as posts and telegraphs; yet the railways remain the property of the separate States. The Constitution recognizes that they are of Federal importance by giving the Federal Parliament power to control their trade and the rates charged on them to some extent. But each State's railways have been for many years State property, constructed with money which the State Governments borrowed, and which is being repaid from the State Treasuries; some were better managed than others, and some States had been less careful than others to build only useful railways; it was considered, therefore, that it would be unfair (at least in the beginning of the Federation) to deprive the wiser and more careful States of property they had made valuable to themselves, and the only precaution taken was to provide that no State may so use its railways as to hinder free communication with the other States.

The Federal Government is in most ways of the same pattern as the State Governments. Its official head is a Governor-General appointed by the Crown. The real governing body is a Cabinet chosen from the Federal Parliament; its head is called the Prime Minister, whereas the heads of State Cabinets are Premiers. The "Lower House" of the Federal Parliament consists of 75 members, chosen by electorates all over Australia, each State being given a number in proportion to its population (except that Tasmania has five electorates, though its population only entitles it to three). The Senate, however, differs from the State "Upper Houses" entirely. It consists of 36 members, six from each State without regard to size, who are elected by the whole body of State electors, but only three at a time. Thus the three Senators who were elected by the New South

Wales electors in 1906 remain Senators till 1913; those who were elected from the same State in 1910 do not retire till 1916. In this way the Senate is supposed to be made a less easily changeable body, since only half its members at most can be turned out at one election.

The departments of the Federal Government, each with a Federal Minister at its head, are the Treasury, External Affairs, Home Affairs (which looks after Federal public works), Defence, Trade and Customs, Post-Office, and that of the Attorney-General. The Prime Minister may be also the head of a Department, but need not be. And there are usually one or two "Honorary" Ministers, who have no Department of their own, but help their busier colleagues or take their places when they need a holiday.

COMMERCIAL RELATIONS.

Although Australia produces hardly any native products of value to the world (except timbers), the soil and climate have been found extremely suitable for growing products imported from other countries. No land in the world produces such fine merino wool: the imported *paspalum* grass thrives wonderfully in the coastal districts. and affords fodder for an ever increasing number of dairy-cows: the wheat and fruit of older lands flourish equally well on the highlands and among the foothills of the island-continent. Besides these, many minerals of value which exist in other countries are also found plentifully beneath the soil of Australia. Her commercial value to the world is therefore that of a storehouse and a farm; from her can be obtained ample supplies of certain materials and food-stuffs, to supplement those procurable nearer to the big populations of the Northern Hemisphere, which need them for consumption or manufacture.

Such of these materials and food-stuffs as come from New South Wales have already been mentioned in Chapter XIX. Table I., in that chapter shows that the most important of them are wool, coal, silver, gold, and copper among the raw materials to be worked up elsewhere, and wheat and flour, meats, and butter among the food stuffs. Except for wool and gold, even Australia is low down among the producing countries, and New South Wales is of course a very small factor: thus the State contains only about a quarter as many cattle as there are in Great Britain alone, and less than half as many as there are in the small South American State of Uruguay. As for wheat, Australia produces only about two-thirds of Canada's crop, and less than two-thirds of that of Spain; and New South Wales is responsible for only a quarter of the Australian crop.* In sheep, on the other hand, Australia in 1908 led the world, rearing more than the United States and the United Kingdom combined; and New South Wales alone was fourth on the list, only the Argentine, Russia, and the United States rearing more than this single State. As for gold, the Commonwealth generally produces between one-fifth and one-sixth of the world's gold-supply (during the South African war, when the Transvaal mines were practically closed, it produced as much as one-quarter); but New South Wales yields barely one per cent.

It is very necessary to understand clearly how these products are distributed among the countries of the world. Note, therefore the figures in the following table:—

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* This comes of the emptiness of the land, not of any infertility.

TABLE I.

DISTRIBUTION OF N.S.W. EXPORTS, 1907. (Value in £1,000s.).

	Butter	Coal	Copper	Gold	Wheat and Flour	Leather	Meats
United Kingdom ...	720	...	611	350	773	200	833
Other British Colonies	13	218	9	380	89	74	187
Total within the Empire	733	218	620	730	862	274	1,020
Belgium	...	...	114	...	...	2	...
France	...	...	47	...	...	...	...
Germany	...	...	7	...	1	...	...
Rest of Europe ...	...	...	...	...	...	1	...
China (incl. Hong-kong)	13	45	59	...	60	2	3
Japan	4	3	...	...	27	...	...
Java...	...	19	...	...	18	1	1
Pacific Is.	5	56	...	...	46	4	22
Philippines... ...	11	155	...	...	58	...	15
United States ...	...	266	...	...	...	...	...
South America ...	...	528	...	...	...	...	...
Rest of World ...	3	18	2	...	20	...	13
Total Foreign ...	36	1,080	229	...	240	10	54
Total, all countries	769	1,298	849	731	1,092	284	1,074

NOTE.—This table is compiled from the official figures for 1907, a fairly normal year. It refers to New South Wales produce only.

TABLE I.—*continued.*

DISTRIBUTION OF N.S.W. EXPORTS, 1907. (Value in £1,000s.).

	Oils	Silver	Skins	Tallow	Timber	Tin	Wool
United Kingdom ...	145	262	462	486	9	301	4,963
Other British Colonies	7	1	16	9	217	87	8
Total within the Empire	152	263	478	495	226	388	4,971
Belgium	...	271	63	7	2	56	2,408
France	...	...	160	2	...	19	3,731
Germany	26	59	32	6	17	7	2,874
Rest of Europe ...	...	46	46	5	...	11	59
China	...	...	...	1	9	...	...
Japan	5	...	5	9	3	...	348
Java...	...	...	...	...	...	...	...
Pacific Is.	...	...	...	...	5	...	...
Philippines... ...	...	...	...	1	49	...	...
U.S.A.	20	...	109	...	7	7	208
South America ...	...	...	...	1	...	...	...
Rest of World ...	...	1	...	...	2	...	...
Total Foreign ...	51	377	415	32	94	100	9,638
Total, all countries	203	640	893	527	320	488	14,609

Studying these figures, we notice that

(*a*) Two-thirds of the State's wool goes to foreign countries, mainly European; more than half its silver also goes to the Continent of Europe, and five-sixths of its coal to countries bordering the Pacific; otherwise the bulk of its exports go to lands within the Empire;

(*b*) *Britain* takes the largest share of all the enumerated products except coal (which she naturally does not want), the precious metals, and timber (which also she gets nearer home);

France, our next best customer, takes wool, skins, and copper;

Germany takes wool, skins, and silver, and a good deal of cocoanut oil, which is made in New South Wales from copra imported from the islands;

Belgium seems to take a great deal of copper, silver, and tin—but most of this probably goes through Belgium into Germany, and should really be added to the German figures;

Of the Pacific borderlands, *South America* takes our coal, *North America* coal, skins, and a little wool, *China* coal, copper, and foodstuffs, *Malaysia* and the *islands* the same. *Japan* takes a little wheat and a steadily increasing quantity of wool.

How do these countries pay New South Wales for what they get? Mainly, as has already been said in Chapter XXI., by sending out manufactured goods that cannot be so cheaply or so satisfactorily produced within the State. (See p. 312 for the figures.) Now the distribution of these imports among the producing countries raises a question of great importance to the Empire. For, when you take goods from a country, you thereby provide employment for its workmen; you enable it, that is, to rear within its bounds a larger number of healthy people than it might otherwise contain. It is obvious that, while the nations of the world are not all inseparable friends, it is good policy to help those who are likely to be our friends rather than those who may be our enemies; and the countries belonging to the British Empire are beginning to see how they may give valuable help to each other by buying each other's goods (when suitable) rather than those of strangers. It is still a matter of political dispute how far this idea of "preference" should be embodied in law, how far merely left to the patriotism of private purchasers. But, seeing that the feeling exists and is growing, it becomes important to notice how New South Wales does in fact distribute her purchases among oversea nations. The following table gives, for the same normal year as before, the actual oversea trade of the State:—

TABLE II.

OVERSEA TRADE OF N.S.W. WITH VARIOUS COUNTRIES (1907).

(Values in £1,000s.).

	*Imports from	Exports to	Total trade with
United Kingdom	11,308	13,688	24,996
New Zealand	1,544	1,480	3,024
India	769	755	1,524
Other British Possessions	968	1,539	2,507
Within the Empire	14,589	17,462	32,051
Belgium	229	3,532	3,761
France	728	4,476	5,204
Germany	1,938	3,686	5,624
Rest of Europe	1,132	338	1,470
China	169	700	869
Japan	303	486	789
Java and Malaysia	131	85	216
Pacific Is.	224	440	664
Philippines	31	312	343
United States	3,458	812	4,270
South America	55	536	591
Rest of the World	60	30	90
Outside the Empire	8,458	15,433	23,891
Total Oversea Trade	23,047	32,895	55,942

* These figures represent goods actually produced in the country from which they were imported.

Two things are at once apparent. In the first place, New South Wales exports a great deal more than she imports: at the first glance she seems to be giving away ten million pounds' worth more than she receives. This is accounted for when you remember what was said in Chapter XXII. about the State's borrowing money for public works. Having borrowed very heavily in past years, New South Wales has both to pay a large sum of money as annual interest, and to repay nearly every year part of the principal. What the State has done, private people have done too, and they also have to pay interest and repay portions of the capital. Moreover, the ships which carry the produce to Europe are nearly all owned outside Australia, and the freight must be paid to those British or foreign owners. These payments are not made in money; instead, New South Wales produce is sent to Europe, and the amounts paid there for it find their way to the pockets of the creditors and shipowners. The complicated nature of the process is further made evident when you notice that Britain, from which we borrow most, and whose ships carry most of our produce, sends us nearly as much as we send her; while we send large surpluses of produce to Belgium, France, and Germany, from which countries we have borrowed nothing, and the United States send a large surplus to us. Imagine, however, that you owe £100 to someone in London, and cannot pay him either in cash or in goods that he wants; if someone in Belgium wants your produce, you can send along £100 worth to him, and tell him to pay the money or its equivalent to the man in London—and the result is the same in the end.

The second point is this: while the State sells its produce to many countries, it does buy its imports mostly within the Empire. It can easily be calculated that 49 per cent. of the 1907 imports came from Britain, and 14 per cent. from the rest of the Empire, leaving nearly

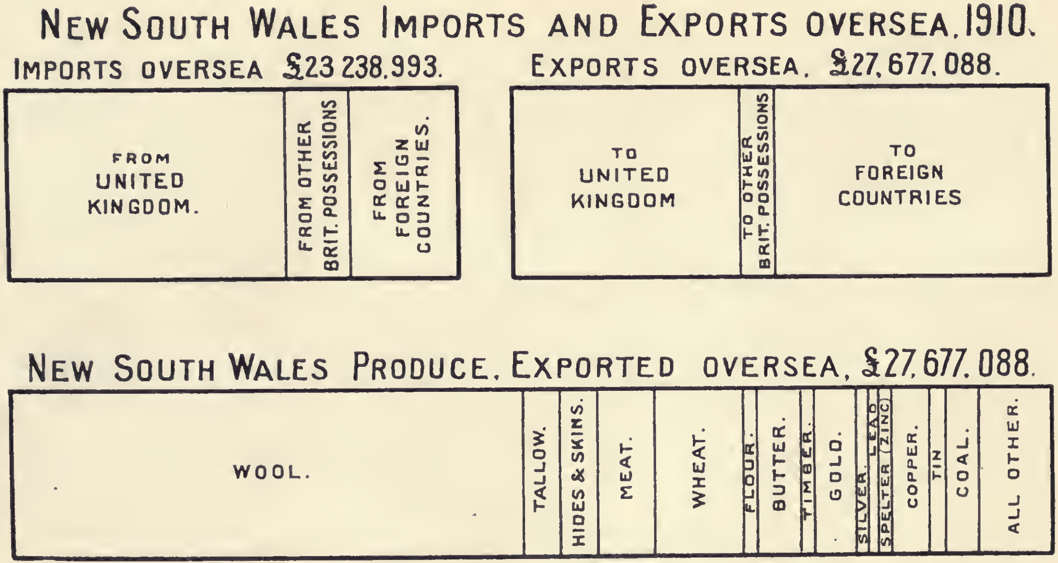

Fig 108. Imports and Export of New South Wales, 1910.

37 per cent. as the share of the foreigner. This tendency, however, seems to be weakening: in 1906 the foreigner's share was less than 35 per cent., while in 1909 it was well above 37 per cent. The figures for all Australia show that Germany sells us every year a greater proportion of our apparel and leather goods, and France a greater proportion of our watches and jewellery, and drugs and chemicals; and New South Wales, which is below the Australian average in her intra-Imperial shopping, probably shares fully in the increased dealings with Germany and France. To counterbalance this diversion of trade from Britain to foreign countries, it has been proposed to let British goods come in at a lower rate of duty than is levied on foreign goods of the same kind: and in 1907 this was arranged by law in connection with certain classes of imports. It is still too early to estimate how much difference has been made by this grant of "preference"; as regards apparel it seems as yet ineffective, as regards machinery and other manufactures of metal it seems to be helping Britain against the competition of the United States. An arrangement has also been made between the Commonwealth and South Africa, by which each colony lets in the other's products at lower rates than affect foreign products; and it is hoped that similar arrangements will soon be made with New Zealand and Canada.

Commercially, therefore, Australia's value (which includes the value of New South Wales) to the world is, as has been already said, that of a storehouse and farm; it is also that of a customer. Its special value to the Empire consists in its being populated mainly by British people, whose natural instinct is to trade chiefly with their own kin; as producers the Australians make wealth (in the shape of foodstuffs and raw material), which can when needed, be devoted wholly to the service of the Empire; as consumers, they help to provide employment for those other Britons oversea who get their living by manufactures.

The Australian's duty to the Empire, of which he is a part is, therefore, of two kinds. He should use all his efforts to improve and develop his own country, politically and commercially, so that it may be filled with healthy, wise, and prosperous folk, able both to govern themselves sensibly and to defend themselves effectively against invaders: for this reason he must learn all he can about the land and the climate and the other conditions under which he has to work. And, besides this, in all acts that affect people outside Australia he should consider first the welfare of his fellow-Britons in other parts of the Empire,—commercially, by buying from them as much as possible to give them full employment; politically, by relieving them of the defence of Australasian waters, by giving no foreigner cause of complaint unless there is urgent reason to do so, and by filling up with his own kinsmen as soon as possible the vacant spaces of the land which he cannot use fully himself.

APPENDIX

TABLE OF THE GEOLOGICAL FORMATIONS OF NEW SOUTH WALES

(W. G. WOOLNOUGH, D.SC., F.G.S.)

AGE.	LOCAL NAME.	SUBDIVISIONS.	DISTRIBUTION.
Cainozoic		River alluvial and delta formations	Along the lower portions of the larger rivers and at various points of the coast line
		Red and black soil plains	See Chapter VI
		Deep leads and diatomaceous earths	In old river and lake beds preserved under sheets of basalt
		Eocene limestones	Continuation into the south-western corner of the state of the very much more extensive formations of this age in South Australia and Victoria.
Cretaceous	Cretaceous	Desert Sandstone	Isolated patches of a once continuous sheet of this formation which formerly covered much of the north-western corner of the State.
		Rolling Downs Beds	These probably underlie the red and black soil plains in the north-western portion of the state, but are not widely developed as a surface formation.

TABLE OF THE GEOLOGICAL FORMATIONS OF NEW SOUTH WALES—*Continued.*

AGE.	LOCAL NAME.	SUBDIVISIONS.	DISTRIBUTION.
Carboniferous	Carboniferous	Stroud and Clarence Town Beds	Along the northern side of the Hunter River Valley.
		Barraba and Bingara Beds	On the southern and south-western parts of the New England Plateau. Perhaps includes the bulk of the New England sediments.
			The Carboniferous of New South Wales is not coal bearing.
Devonian	Devonian	Mount Lambie Beds	Reddish fresh water and marine sediments between the Blue Mountains and Bathurst.
		Murrumbidgee Beds	Volcanic Rocks, and richly fossiliferous limestones, largely developed on the Murrumbidgee River, near the Federal Capital Site.
			Very numerous areas of Devonian rocks are known, but in many instances their correlation is doubtful.
			Notable Devonian areas are Mount Lambie, Yalwal, Majors Creek, Murrumbidgee, Tamworth, and Cobar.
Silurian	Silurian	Cave Limestones Yass and Bowning Beds	The great limestone caverns of Yarrangobilly, Wombeyan, Jenolan, Abercrombie and Wellington, are in this formation. Richly fossiliferous shales, limestones, and tuffs developed typically near Yass. Similar beds occur near Molong. Vast areas of unfossiliferous slates in different parts of the state were originally referred to the Silurian System. Detailed examination shows that many of these slates belong to other formations.

Age.	Local Name.	Subdivisions.	Distribution.
Jurassic		Talbragar Beds	A local out-crop of small size, on the Talbragar River near Mudgee, containing beautifully preserved plant remains and fossil fish.
Trias-Jura	Clarence Series and Artesian Beds	Upper, Middle and Lower Clarence Beds	Occupying a considerable area in the extreme north-eastern corner of the state and extending into Queensland where they constitute the Ipswich Coal Measures.
		Artesian Beds	Exposed over a wide area on the western flanks of the New England Tableland.
Triassic	Hawkesbury Series	Wramamatta Shales Hawkesbury Sandstones Narrabeen Beds	Freshwater beds developed in the Sydney and Blue Mountain area.
Permo-Carboniferous	Permo-Carboniferous	Newcastle Coal Measures Dempsey Beds Tomago or East Maitland Coal Measures Upper Marine Beds Greta Coal Measures Lower Marine Beds	The productive coal measures of New South Wales are all in this system, which is typically developed in the Hunter River Valley. The main area extends as far as Gunnedah in a north-westerly direction. Another extensive development is in the Illawarra District. Less well known areas are those of the Manning and Macleay Rivers and parts of the New England Plateau, in which the characters of the beds are quite different from those in the type district.

TABLE OF THE GEOLOGICAL FORMATIONS OF NEW SOUTH WALES—*Continued.*

AGE.	LOCAL NAME.	SUBDIVISIONS.	DISTRIBUTION.
Ordovician	Ordovician		Quartzites and black slates with *Graptolites* occur at several places. The number of known localities has been increased considerably of recent years. Notable areas are near the Victorian borders in the Snowy River District, the Shoalhaven River at Marulan, Peak Hill, Cadia, Myall Reefs.
Cambrian	Cambrian		A continuation of the very extensive development of Cambrian Rocks in South Australia is met with in the Barrier Ranges of New South Wales.
Pre-Cambrian	Pre-Cambrian		Crystalline schists of the Barrier Ranges, including those in which the Broken Hill lode is situated. A great series of gneisses near Cooma is probably Pre-Cambrian in age.

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